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Development Strategies of Re-Urbanization for Sustainable Extensive Towns

Francesco Orsi

Doutoramento no ramo de Arquitetura

Especialidade de Desenho e Computação

Orientadores Científicos:
Doutora Cristina Soares Ribeiro Gomes Cavaco
Doutor José Nuno Dinis Cabral Beirão
Doutor Jorge Alberto Lopes Gil

Tese especialmente elaborada para a obtenção do grau de doutor
Ano 2020

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Presidente do Júri:
Doutora Cristina Delgado Henriques,
Professora Auxiliar, Faculdade de Arquitetura da Universidade de Lisboa;

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Professor Auxiliar, Faculdade de Arquitetura da Universidade de Lisboa;

Doutora Cristina Soares Ribeiro Gomes Cavaco,
Professora Auxiliar, Faculdade de Arquitetura da Universidade de Lisboa;

Doutor Frederico Amado de Moura e Sá,
Professor Auxiliar Convidado, Universidade de Aveiro.

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“To my wife Vania, my family and to Jorge Gil without whom this thesis would have never been possible”

SUMMARY / ABSTRACT

The Portuguese territory displays a wide-spread urban dispersion that encouraged land-consuming practices, causes high infrastructural costs and poses new issues to urban and regional policies. The subject of the present research is the mitigation of the negative effects of extensive urbanization of the Portuguese territory focusing on processes of re-urbanization / intensification for such dispersed territories. In this respect, this work brings a novel contribution to the process of concealing and implementing territorial development plans capable of incorporating sustainable development strategies for different kinds of dispersed territories, integrating the traditional planning tool in use in local planning.

In order to do so, the present work developed a methodological tool – bringing together network analyses, density/dispersion assessment tools and a territorial capital analyses – that constitutes a valid decision-making support system capable of helping planners and stakeholders to address the economic, social and governance challenges posed by dispersed territories. In order to do so a set of quantitative methods was developed to assess the territorial capital of different territories (both compact and dispersed) to identify their inherent characteristics, vocations and potentials for development, measuring and monitoring the fluctuations in a selected list of territorial indicators as affected by the introduction of different development scenarios.

By analyzing the territory from a configurational and spatial-economic perspective rather than just from a morphological perspective, the present research tries to bring an original contribution to the process of crafting a new operative framework capable of dealing with the dispersed territories assisting planners and administrations to take informed decision on various topics, from planning to governance. A case study, the municipality of Sintra, highly representative of the current issue of the territorial dispersion in Portugal, has been analyzed and discussed. The development of a novel framework for the assessment of different development scenarios that will incorporate the concept of territorial capital will guide in finding strategies and tools for strategic re-urbanization or deconcentrated sectorial development of the territory in analysis, hopefully producing more sustainable urban environments with potential for vital human interaction, i.e. a better “urbanity”.

KEYWORDS: Extensive Urbanization, Territorial Capital, Strategic Spatial Planning, GIS, Decision-making Support, Re-urbanization.

RESUMO

O território português apresenta uma dispersão urbana generalizada que incentiva práticas de consumo do solo, causa altos custos infraestruturais e coloca novos problemas nas políticas urbanas e regionais. O tema da presente pesquisa é a mitigação dos efeitos negativos da urbanização extensiva do território português, propondo ferramentas para processos de reurbanização / intensificação para tais territórios dispersos. A esse respeito, este trabalho traz uma nova contribuição ao processo de conceição e implementação de planos de desenvolvimento territorial capazes de incorporar estratégias de desenvolvimento sustentável para diferentes tipos de territórios dispersos, integrando as ferramentas tradicionais de planeamento em uso em contextos de planeamento local.

Para isso, o presente trabalho desenvolveu uma ferramenta metodológica que reúne análises de rede, ferramentas de estudo de densidade / dispersão e análises de capital territorial e que constitui um sistema válido de apoio à tomada de decisão capaz de ajudar planeadores e stakeholders a abordar questões econômicas, desafios sociais e de governança colocados pelos territórios dispersos. Para isso, foi desenvolvido um conjunto de métodos quantitativos para avaliar o capital territorial de diferentes territórios (compactos e dispersos) identificando a suas características, vocações e potenciais no que respeita ao desenvolvimento territórial, medindo e monitorando as suas flutuações em uma lista selecionada de indicadores territoriais afetada pela introdução de diferentes cenários de desenvolvimento.

Ao analisar o território de uma perspectiva configuracional e econômico-espacial, e não apenas de uma perspectiva morfológica, a presente investigação tenta trazer uma contribuição original ao processo de elaboração de um novo *framework* operacional capaz de lidar com os territórios dispersos, com o intuito de constituir um instrumento de surporte para planeadores e administrações publicas no âmbito da tomada de decisões informadas sobre vários tópicos, do planejamento à governança. Um *case study*, o concelho de Sintra, altamente representativo da questão atual da dispersão territorial em Portugal, foi analisado e discutido. O desenvolvimento de um novo *framework* para a avaliação de diferentes cenários de desenvolvimento, que incorpora o conceito de capital territorial, guia na busca de estratégias e ferramentas para reurbanização estratégica ou desenvolvimento setorial desconcentrado do território em análise, produzindo, esperançosamente, ambientes urbanos mais sustentáveis com mais potencial para uma interação humana vital, ou seja, uma melhor “urbanidade”.

PALAVRAS CHAVE: Urbanização extensiva, capital territórial, ordenamento do território, SIG, suporte à decisão, re-urbanização.

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INTRODUCTION

Background

Europe has a long history of urban agglomeration, being one of the most urbanised regions on earth. At the present time, approximately 75% of the European population live in urban areas - as opposed to 55% worldwide - while still enjoying relatively easy access to extensive natural or semi-natural landscapes. Europe has built much of its competitive success upon the agglomeration advantage generated within its cities. Its stunning urban landscapes and historical cities are regarded one of the world's most desirable and healthy places to live on earth.

The urban future of Europe, however, is currently a matter of concern. What concerns more the European Union and the national policy-makers is the rapid transformation of non-urban land into urban land. This phenomenon is present at an increasing speed in most of the EU countries. This due to an exponential growth of areas that are mainly on the fringes of major cities and that suddenly become urbanized. Sudden relocation out of urban areas into low-density areas is one of the many causes of urban dispersion. Often such territories take the shape of monofunctional areas hosting car-dependent communities.

In fact, more than a quarter of the European Union's territory has now been directly affected by urban land use (Kasanko et al., 2006). The European population is turning increasingly urban so that the various demands for land in and around cities, as a result, are becoming increasingly acute. Cities are spreading in a scattered way throughout Europe's countryside, minimising the time and distances between and in-and-out of the cities. Land take by the expansion of residential areas is the main cause of the increase in the coverage of urban land in Europe. Agricultural zones and, to a lesser extent, forests and natural areas, are disappearing in favor of artificial surfaces. This affects biodiversity since it decreases habitats and fragments the landscapes that support and connect them. The problem of urban expansion, fragmentation and dispersion is

becoming more and more relevant in the vast majority of the countries of the European Union but also in the world (OECD, 2012a).

The Portuguese context

During the last four decades, the insurgence of low-density developments and discontinuous urban fabrics hastened the problem of territorial sustainability in Portugal (Marques, 2002) and especially in the areas between the two major cities, Lisbon and Oporto, and in the southern conglomeration of Algarve.

The World Bank calculated that in 2015 the percentage of the urban population in Portugal reached 64.468% ("Urban population (% of total population)—Portugal | Data," n.d.) most of this population lives in dispersed territories along the coastal regions comprising the metropolitan areas of Lisbon and Oporto. Such urban dispersion causes negative effects to Portugal's territorial sustainability, regional economy and social cohesion(C. Cavaco et al., 2015; Direcção-Geral do Território, 2016).

Urban dispersion, although being a common phenomenon all over the most populated areas of Europe, is particularly evident where countries or regions have benefited from EU regional policies. Such phenomenon is also not directly linked with demographic growth but it is also present in regions whose current demographic trend is shrinking. That suggest that land consumption is increasing faster and sometimes with no link to demographic growth. "Although the population is decreasing in many regions of Europe, urban areas are still growing in those areas, notably Spain, Portugal and some parts of Italy. Conversely, moderate increases of population accompanied by a large expansion of urban areas can be observed in Spain, Portugal, Ireland and the Netherlands" (Kasanko et al., 2006, p. 11)

Problem Statement

The European territory, while being traditionally the expression of an urban culture that served as an archetypical paradigm for the compact city model (Jenks, Burton, & Williams, 1996), is now increasingly characterized by a diffused urban dispersion.

On the other hand, the Portuguese territory displays – especially in its coastal central regions - a diffused urban dispersion that encourages land-consuming practices, causes high infrastructural costs and poses new issues to national and regional policies (Carvalho & Abreu, 2011; Portas, Domingues, & Cabral, 2011). The lack of strategic coordination and instruments for integrating goals of sustainable development (Cabral & Marques, 1996) in territorial planning at municipal supra-municipal level have facilitated for decades the development of undesirable spatial phenomena in Portugal, like a high rate of soil consumption and urban dispersion.

New methodological approaches as well as a renewed planning and policy framework are urgently needed in order to tackle the issues related to the pervasive urban dispersion both in Portugal and abroad.

Research aim

Given the present situation of urban dispersion throughout some of the most populated regions of continental Portugal, the challenge now is to rethink, reconfigure and restructure dispersed environments, seeking for new means of consolidating, densifying and enhancing coherence of existing fabrics rather than expanding their urban footprints. In fact, such challenge calls for novel paradigms of territorial planning, more intertwined with strategic planning rather than having just a normative character, while new operational tools enable a more integrated and holistic approach to the study of a specific territory and its planning for a sustainable development (Yigitcanlar & Teriman, 2015). In order to understand how to intervene in such contexts a truly integrated approach capable of taking into account geographic and environmental features and well as economic and social variables is therefore needed.

The latest land regime reforms promoted by the Portuguese government imply a new classification of urban versus rural areas which provides the opportunity to restructure the relation between these two extremes as to rethink the development conditions for the extensive territories that lie somehow between the rural and urban realms and that constitute a large portion of the Portuguese built environment.

The present research tries to bring an original contribution in the process of crafting new methodological tools capable of dealing with the dispersed territories in an holistic way, supporting the planning phase as well as acting as monitoring and benchmarking systems for the governance tasks. Pivotal to this, is the analysis and classification of extensive low-density fabrics highlighting the potentials and the vocations of each territory in order to set the most adequate development strategies for it. This approach may prove to be particularly useful for rethinking extensive suburban territories' densification conditions in order to enhance the positive growth of their territorial capital and its sustainability over time.

The primary aim of this research is therefore:

- to propose an appropriate conceptual and operational framework capable of guiding through the decision-making process of developing municipal and supra-municipal masterplans that take into account the territorial context of the region, its territorial capital and that are proving to be capable of better translating generic strategic plans to actual territorial policies for municipalities or wider administrational units. All this in a perspective of re-urbanization of extensive territories and territorial sustainability on the long run.

Associated with this aim, are some secondary aims that follow:

- To develop an analytic framework capable of incorporating all the different dimension of the territorial capital of Sintra allowing for an holistic view over the territorial development of Sintra;
- To classify the different degrees of dispersion of Sintra's built-up areas conglomerates;

- To classify the different locations of Sintra's territory according to their territorial capital scores;
- To prove how an operative framework as the one proposed could come into play in the process of developing a PDM for a municipality willing to explore the potential of its territorial capital and contrast unplanned developments;
- To deliver such outputs in an way that would make the experiment easily reproducible using open data and open software, keeping in mind always the scalability of the project and its feasibility in a regional planning context.

Research questions

The foundational questions that this research will address are the following:

- What are the elements that make a location thrive, making it suitable for economic investment, increase in livelihood and re-urbanization processes?

From analyzing in an holistic way territorial capital of that location, relating it with the regional metabolism in which the location in inserted, we can discover potentials and vocations of the given location. From here other questions emerge, namely:

- How can we contrast the territorial dispersion by planning more lively and diverse urban conglomerates?
- Upon which ground can we defend the choice on which location are worth to be re-urbanized and which are not?
- How can we measure and spatialize the elements that concur to the definition of the territorial capital of a specific region in order to be able to embed those findings in a planning process?
- How can we translate generic strategic plans to detailed territorial development plans?
- How can we design an analytical framework capable of guiding in the decision-making process of developing municipal and regional masterplans that can be easily scalable and reproducible?
- Is it possible to integrate a normative tool with strategic development tool inside of a PDM process of revision?

Audience and relevance

In general, this work is targeted at planning researchers and practitioners with an interest in introducing a territorial analysis framework capable to incorporate the different dimensions that constitute the territorial capital of a municipality or a region.

In particular, this approach will be of greater interest to those applying quantitative methods to the analysis and evaluation of regional environments, especially those interested in introducing an holistic approach to such analyses.

Beside such audience the work can be of high interest to those involved in planning practice coming from different backgrounds, namely urban planning and economic regional development, and willing to incorporate their analyses into a wider framework

capable of making an holistic approach to the issues of the specific territory more viable and easier to communicate between different areas of knowledge.

This audience should include practitioners involved in strategic planning, master planning, and neighborhood design, transportation design, urban development. Local stakeholder and administrators, whatever their background, will hopefully find useful insights, guidance and tools in the outputs and conclusions of this work.

Societal relevance

In recent years, the concern with sustainable development and the issue of territorial dispersion increased, calling for new approach and new methods to cope with the dispersion and to plan a sustainable territorial development based on the territorial capital of the place at hand. The proposed framework implemented in a Geographic Information System (GIS), and integrated with an appropriate evaluation framework, is a suitable tool for planning support the definition of a development strategy capable of capturing the opportunities and the vocations that can come from a detailed analysis of the territorial capital. Such a tool can be used to understand the present conditions and to test scenarios, by creating different profiles for different projected land uses testing the possibility to achieve such results through the current plan. The proposed evaluation framework is an example of such a planning support tool, capable of providing an understanding of the characteristics of existing urban areas in their regional context, and comparing actual performance against potential outcomes determined by this context. This contextual knowledge allows focusing on urban areas with greater untapped potential for change, and identifying the specific type of intervention required.

The proposed evaluation framework is based on a system of territorial capital indicators, which is the format most commonly used in practice for evaluating and monitoring territorial capital and sustainable urban development (SUD).

GIS platforms are becoming increasingly accessible and user friendly: as a result they are being widely adopted by local governments to support planning and decision making, and their use is becoming fundamental to comply with data management and sharing standards, such as the EU INSPIRE directive. The GIS model and methods developed in this work make use of open data, user-generated geographic information publicly available on the world wide web. It is also used an array of open source software that are accessible to the general public, making the work more easily reproducible but also adaptable to other geographic locations, without high financial demands.

Thesis Outline

The work presented here was divided into four phases:

- the Analytical phase, involving a literature review, as well as the practice review, needed to set a debate over the general approach of the research and a contextualization of the case study;
- the Methodology phase, in which the research design is outlined, the individual methods for the territorial analyses are illustrated and the data treatment is described;
- the Application phase, where the theoretical model is put in practice through the testing of two implementations developed as proof of concept of the theoretical model: a spatialization of a SWOT analysis and a territorial profiling for scenario evaluation;
- finally the Discussion phase, in which a critical reflection on the results of

the conceptual model and the scenarios evaluation results is provided.

The first phase, the Analytical phase, is where the literature review on the central topics of the work as highlighted in introductory section takes place, informing the subsequent stages of the study from a theoretical perspective.

For the present research, the most central topics to be investigated through the existing literature are the subject of the extensive territories as well as the need of an holistic approach to the issue of territorial dispersion and of a quantitative approach in the study of territorial dynamics and potentials, employing an integrated approach and embracing the concept of territorial capital.

Also part of this phase is a practice review which informs the methodological aspects of the work and sets a debate on the opportunity of the use of such quantitative methods of territorial analysis and modelling. Here the most common planning methods that are currently used in the planning and governance practice are described and discussed as well as the most appropriated analytic methods to tackle the research problems and goals, presented in Chapter 1. In addition to this a contextualization of the case study, Sintra, helps understanding the choice of the case as well as guiding the reader through the most important issues and topics related to the development of the revision of Sintra's PDM.

The following phase, Methodology phase, deal directly with the case study of Sintra, analyzing one after the other the datasets selection and treatment, the foundations of the theoretical model with the selected methods for territorial analysis and the characterization of each indicator in order to get to a level of understanding of the different variables at play in the selected territory detailed enough to support the design choice of the subsequent scenario evaluation phase. This phase also describes the process that led to the definition of the selected indicators and also illustrates the process involved in calculating the whole range of indicators of territorial capital.

The Application phase illustrates the two applications of the model, the spatialization of the SWOT analysis and the territorial profiling for scenario evaluation. The results of such applications are then mapped in order to assess their distribution. This concludes the quantitative work, developing a method for contextual scenario evaluation of

potential and performance for development as well as for re-densification. Such framework is at the core of this research and represents one of the key contributions of this work.

The subsequent and final step has been the Disccusion phase of such territorial characterization. Here the results of the territorial matrix have been carefully analyzed, discussed and compared with the indications given by Sintra's territorial development model proposed in the revision of Sintra's PDM.

The result of such methodological progression – from the raw data to the informed interpretation – led to a deeper, evidence-based understanding of the territory and its dynamics, potentials and weak points. Such level of understanding could only be achieved with the employment of such holistic view and such objective analytical methods.

PART 1 – LITERATURE REVIEW AND CONTEXTUALIZATION

1. THE PHENOMENON OF THE EXTENSIVE URBANIZATION

1.1 Extensive urbanization: a conceptual framing

In the recent years, the concern that the transformation of the traditional compact city into a new type of dispersed and fragmented urbanization – as a consequence of the recent suburbanization processes – gave rise to an important debate among geographers, urbanists and environmentalists (Monclús, Dematteis, et al., 1998).

It is unquestionable that extensive urbanization is a mode of inhabiting the landscape that became the dominant mode of settlement of contemporary society (Alvaro Domingues, 2008). Yet, such urbanization does not imply any adherence to the concept of city, as we traditionally know it, anymore. The loss of certain territorial frictions – typical of the pre-automotive era - triggered diverse dynamics of territorialization that have very little in common with what we traditionally recognized as city.

As Domingues correctly points out "the city has now been replaced by extensive urbanization, made possible by the provision of infrastructures, which can be likened to a system of devices designed to colonize a territory immersed in a process of profound socio-technological transformation." (Domingues, 2013, p. 24)

Françoise Choay, in truth, calls our attention to what she considers a great anachronism today: to call the urban spaces in which we inhabit today "city", as she argues in the section,*"Ville": un archaïsme lexical*" of her *Pour une anthropologie de l'espace* (Choay, 2006). As the author pointed out, we should therefore admit "*la disparition de la ville traditionnelle, et de s'interroger sur ce qui l'a remplacée, [...] sur la nature de*

l'urbanisation et sur la non-ville qui semble être devenue le destin des sociétés occidentales avancées?[1]" (2006, p. 167).

To support her thinking, Françoise Choay looks at the etymology of the French word *la ville*. The term *"ville"* comes from the Latin "*villa*". The Roman *villa* was a large country residence built for the upper class in the Roman Republic and Empire. It was a fragment of urban society temporarily dislocated in the countryside. The French term *ville* therefore reminiscences the link between the city and the countryside, a relationship of complementarity that will be broken during the Industrial Revolution with the exponential growth of the population and the cities. From there, it has been then a *crescendo* of an urbanization processes that led to the paradoxical condition of the "death of the city" in which the "city" is substituted by the "urban", a new entity that in her view, characterizes what Melvin Webber calls the Post-City age (Webber, 1968). In fact, Webber already in 1968 calls "city" an anachronism: when referring to the concept of urban, he states "we still have no adequate descriptive terms for the emerging social order, and so we use, perforce, old labels that are no longer fitting".

More than a simple change of scale, the phenomenon of the extensive urbanization is shifting the paradigm of what we traditionally know as urban context, shacking the way we look at the dichotomies like city/countryside or urban/rural. Unlike in the iconographic and ideologic program of Ambrogio Lorenzetti in his Effetti del Buon Governo in Campagna e in Città (Siena, 1340) – where city and countryside work together and complement each other to form a symbiotic *unicum* in which every part plays fundamental role for the functioning of the whole system – in the extensive urbanization this symbiotic dichotomy city/countryside is shaken by the emergence of a new magma of dispersed urbanization, or rurbanization (cfr. Bauer & Roux, 1976) where it is difficult to identify which elements pertain to the city and which to the countryside.

Such dispersed urbanization obeys to rules that are totally different than the ones of the confined city. Rurbanization here doesn't imply the hybridization of two pure entities – the city and the rural – but rather more complex process that resemble the biological transgenic, where a territory can incorporate "genes" that belong to different realms whether it is the city or the countryside. As we are unable to overcome the city/country dichotomy, everything is attributed to a process of "degeneration". Here, the inability to overcome the city/country dichotomy gave rise to a negative discourse fueled by the trauma generated by the loss of these two archetypical entities – the city and the countryside – in which the lack of novel updated perspectives over the contemporary territories renders the study and the governance of them much more difficult.

As Alvaro Domingues stresses "A grande escala territorial da urbanização extensiva não é apenas a representação da urbanização em territórios "desconfinados", é, sobretudo, um âmbito geográfico pertinente para perceber as múltiplas dimensões que estruturam as dinâmicas e processos, i.e. o campo de forças territorial que actua sobre a escala micro dos "lugares" e das suas transformações[2]" (Alvaro Domingues, 2008, p. 1)

1.2 The urban unbound: a territorial and conceptual trespassing

It is important at this stage to correctly frame the phenomenon that is at the center of our interest: the territorial and conceptual trespassing of the urban beyond the city. The concepts – and the terms – of "city" and "urban" got increasingly banalized, gaining more and more a character of polysemy that renders the use of these concepts trickier that what it used to be. The result is a paradoxical situation in which we end up using "sponge-like" concepts that, due to the excessive polysemy they contain, loose clarity and scientific rigor, producing an illusion of objectivity that hides a ambiguity and misinterpretation. In what concerns to urban planning, we have two main problems: territorial and conceptual trespassing of the urban beyond the city. (Alvaro Domingues, 2008).

The term "city" designates a built-up territory with precise boundaries, a kind of container of the society it produces it, organizes it and uses it. This archetypical city was the result of the agglomeration pressures that shaped the way our territory has been structured. Before the Post-Industrial revolution, the concentration of population and capital offered great advantages, economic and social ones, and, in essence, those opportunities were the reasons that have led to the emergence of the compact city. With the rise of automotive industry and the loss of most of the territorial frictions, physical proximity or physical agglomeration are no longer necessary preconditions for intensification of relations and of material and immaterial exchanges.

It can be argued that while on the one hand the advantages of the agglomeration often turned into disadvantages (congestion, times and transport costs, environmental quality, cost of living, etc.); on the other hand, the same benefits of agglomeration (opportunities, information, socializing, etc.) apparently could also be achieved without agglomeration. This is the thesis put forward by Francesco Indovina in his seminal text "La città diffusa" (Indovina et al., 1990).

As Françoise Choay points out, the mutation of the "city" to the "urban" was not done simply by enlarging the city. The "urban" introduces another spatial and social order characterized by centrifugal forces (but also by neo-centralizations), by extensiveness, by discontinuity, by fragmentation (Choay, 2006). We call this phenomenon the "explosion of the city" (cfr. Font et al., 2004), or the "emergent city" (Dubois-Taine & Chalas, 1997) or "extensive urbanization" as Alvaro Domingues calls it.

In fact, in whatever way we call it, it is important to acknowledge the territorial and conceptual shifting that this paradigm change introduced. As Domingues correctly points out "Extensive urbanization characterizes most of the urban contemporary field. Contrary to the forms and dynamics of canonical cities, extensive urbanization is an unconfined geographical pattern, a kind of nebula, where all seems chaotic. In what concerns to urban planning, we have two main problems: territorial and conceptual trespassing of the urban realm." (Alvaro Domingues, 2008, p. 12).

From a territorial point of view, the extension of infrastructure in an extensively urbanized territory produces forms of settlement and uses that connect directly to this infrastructure, without the clarity and the formal continuity of what is called city. From a conceptual point of view, the extensive urbanization represents a way to rethink and reformulate the dichotomy city/countryside or urban/rural. In this respect, rather than re-affirming the inferiority of the periphery and the suburb over the city, the term extensive urbanization acknowledges the existence and the value of the urban beyond the city walls. Using a metaphor from another scientific field, the territory becomes an hypertext organized according to the logics of relation and connectivity. In fact if we persist in employing the same old concepts and theoretical frameworks of analysis, such as the old dichotomy urban/rural, we may risk to not be able to understand what is happening now and even more not to be able to plan or regulate these new realities.

The profound changes that took place in the traditional processes of city growth, in particular, transformed the way the European city is shaped – and conceived. The structure of many European cities and territories, in fact, changed greatly during the last decades progressively abandoning the archetypical compact city model, typical of the traditional European city. The main novelty in the process of city growth in the European territories has been the emergence of new phenomena of dissolution - such as low density settlement patterns, leapfrog developments, spatially segregated land uses - that generated novel urban and territorial morphologies, new "landscapes" of low density character. (Indovina, Doria, Fregolent, & Savino, 2009)

Such dynamics constitute a trend which advances at higher or lower speeds, with different types of development, depending on the specific conditions of each region that is present all over Europe – and beyond.

However, this overarching trend however cannot be assimilated to other apparently similar cases, such as the phenomenon of the urban sprawl in North America which is characterized by totally different causes and results.

1.3 Extensive urbanization: a polysemic terminology

The debate on the “explosion of the city” (cfr. Font et al., 2004) marked the last quarter of the 20th century. In fact, as Cristina Cavaco correctly points out “it is of general consensus that last decades have brought deep transformations into the spatial organization of cities. Beyond the changes in demographics and population density, critical changes have happened in the form of cities, namely throughout phenomena such as the urban sprawl - low density settlement patterns, leapfrog unplanned developments, spatial segregated land uses, large outward incremental expansion, widespread commercial strips, disseminate land ownership and land uses governance (C. S. Cavaco, 2014, p. 216)” All these phenomena, while representing different aspects of the aforementioned explosion of the city, describe different processes and different territorial dynamics. For this reason they cannot be mistaken by synonymous concepts and applied in a generic way.

Terms like “città diffusa” (Indovina et al., 1990), “generic city” (Koolhaas, Mau, & OMA, 1998), “global city” (Sassen, 2008), “metapolis” (Ascher, 1995a), “city of bits” (Mitchell, 1996) or “Zwischenstadt” (Sieverts, 2003) came about to designate and characterize novel emerging phenomena, describing different aspects of the more generic and overarching process of the extensive urbanization of our territory and the changes it brought to our society.

However, the accumulation of such theories and expressions somehow increased the confusion around the meaning of the phenomenon. As Álvaro Domingues (2008) pointed out the issue of extensive urbanization is highly misinterpreted and generically debated: it lies in a huge tangle of concepts where it is difficult to know what it is about and how it has to be approached. This statement may seem paradoxical, given the supposed consensuses that exist around it. However, it is relatively easy demonstrate that such consensus, in fact, relies on a set of concepts that invariably fall into two problems: first, the over-generalization of the concept, secondly, an excessive polysemy.

The over-generalization of concepts like city, urban landscape, urbanization translates into the use of "meta-concepts" which, because they are so general and abstract, produce the illusion of containing all phenomenology of the real, and end becoming real contradictory. As Umberto Eco interestingly explains in his *Kant e l’Ornitorinco* (1997) the duplicity of taxonomies is such that they can be very useful when reality fits to the conceptual categorizations of the scientific knowledge that generated them, but on the other hand, are extremely dangerous when the reality they should describe does not fall in any of these categories, creating a big impasse and a paradox of classification.

This is what happens with the concept of extensive urbanization: it is a (almost) completely new phenomenon that doesn’t fall into the usual categories of city/countryside therefore the absence of any specificity in the taxonomy generates confusion and lack of adequate categorization when it comes to create normative guidelines of urban planning and thus to plan adequate intervention.

One must be very careful when naming the phenomena that populate the ecosystem of the extensive urbanization because most of these terms carry a specific meaning that relates to specific urban dynamics and contexts. As Alvaro Domingues (2008) remembers: “it is not the same to talk about suburban sprawl in the USA, Ville Emergent (Dubois-Taine & Chalas, 1997), Metapolis (Ascher, 1995), Città Diffusa (Indovina et al., 1990)”.

For the sake of this research it is of paramount importance to summarize the innumerous contributions around these topics in order to trace a genealogy of the concept that is the object of the present work: the *extensive urbanization*.

1.4 Low-dense, dispersed, diffused: a terminological disambiguation

As Antonio Font Arellano stresses in his text *Morfologías metropolitanas contemporáneas de la baja densidad* (2007) the indiscriminate use of terms like "low

density city", "scattered city", "diffuse city" or "density / compactness", as if they were equivalent concepts, involuntarily contribute to some terminological confusion.

Firstly, the problem is that the equivalence of the terms "low density" and "dispersion" is very widespread, generating terminological confusion. When both terms are used in conjunction with the word “city”, we are automatically linking that specific settlement to the idea of city, assigning to it city-like qualities, when it may be more appropriate to speak of “urban”. Following this line, it would respectively better to talk about “low density urbanization” - because of its low urban content - or “dispersed urbanization” - because of its dispersed spatial structure in comparison to compact settlements, instead of low density city or dispersed city.

Secondly, the indiscriminate use of the concept of “diffused city”, coined in the Italian urban planning *milieu*, used for the identification of specific forms of urban development stemmed from certain rural structures, leads to the equivalence between the terms “dispersed city” and “diffused city”. Although the dispersion is a spatial condition of the urban structure and diffusion refers to the extension of certain urban traits or values to formerly countryside areas, without both having to be necessarily of low density character.

Moreover, in the current discussion between the traditional “compact city” or the present “dispersed city”, discontinuous or fragmented, the term “compactness” and “density” is often used interchangeably disregarding the fact that they are two different conditions. An urban settlement may be compact and have a relatively low density, like most of the rural centers in our countryside.

Therefore, as Font (2007) emphasizes, in order to avoid this terminological confusion, expressions such as “low density”, “dispersion” and “diffusion” should be reserved to explain the specific characteristics of different kinds of urbanities.

Thus, “low density” would refer to settlements whose population or build intensity in relation to their area is below the average of similar settlements.

By "dispersion," we mean the relative position in the space of individual settlements, fragments, or elements that generate a discontinuous spatial structure. Dispersion is a topological condition, which does not need necessarily be associated with low density.

Finally, by "diffusion" we understand a condition of transmission or distribution of urban characteristics or values to the former countryside.

In the present work we will make use of these expressions in such a way, so that they can be clearly defined and distinguished from each other.

Moreover, it is important to notice that the differential nature of each one of them means that the problems that they pose to urban planning are also different.

1.5 Towards a new landscape of extensive urbanization

During the twentieth century the city passed from being simply a large compact form of human settlement to being a transportation network, a network of different relationships, a territory of events. In this process the city transformed into something else, the “urban” as Françoise Choay would call it. In fact, many theorists already predicted the dissolution of the city. The urban condition is in truth increasingly transcending the city as a physical boundary and morphological structure. From this assumption we understand that “city” and “urban” – as Choay calls them – are two aspect of the same phenomenon in which there is no right or wrong just driving dynamics and temporary equilibriums.

As Domingues points out: “The dramatic increase in mobility (physical and informational) allows for modes of organization that were previously very dependent on physical proximity and agglomeration. The loss of certain territorial frictions - translated in the concepts of flow space or relational space – opens the door to very diverse logics of territorialization and spatialization of the different ways of social organization. The large territorial scale of extensive urbanization is not only the representation of a urbanization in "unconfined" territories, it is, above all, a relevant geographic scope much relevant in order to perceive the multiple dimensions that structure the dynamics and processes, i.e. the territorial force field that acts on the micro-scale of the "places" and their transformations.”[3] (2008, p. 1)

It is important to notice here that the tendency to nostalgically looking at the traditional compact city as the product of a “golden age” of urban history is a fallacious habit. As Sieverts stresses out, it is essential "to disenchant the myth of the Old City," and to face the reality of a new urban paradigm (2003). In fact, the idea of an extensive urbanization that spread over the traditional limits of the city has a long history in the

[3] "O aumento dramático da mobilidade (física e informacional), permite modos de organização que antes estavam muito dependentes da proximidade física e da aglomeração. A perda de certos atritos territoriais – traduzida nos conceitos de espaço de fluxos ou espaço relacional – mobiliza lógicas muito diversas de territorialização, de espacialização dos modos de organização social. A grande escala territorial da urbanização extensiva não é apenas a representação da urbanização em territórios “desconfinados”, é, sobretudo, um âmbito geográfico pertinente para perceber as múltiplas dimensões que estruturam as dinâmicas e processos, i.e. o campo de forças territorial que actua sobre a escala micro dos “lugares” e das suas transformações.”

twentieth century. The first one to conceive a city not through its form and its limits but as a network molded by car transportation has been Franck Loyd Wright with his "Broadacre City, A New Community Plan" (1935). Later Patrick Geddes referred to the uncontrolled expansion of London as an artificial reef. The concept of Megalopolis by Gottman also follows the same line adding to it the notion of "transactional city" (1961). All these authors, either by reporting the dissolution and the dispersion of the city under the pressures of social and economic dynamics shaping the territory in a novel way, either by envisioning and advocating the rise of a new territorial order based on different kinds of social utopias, stated the passage to a new urban era. Melvin Weber in his Nonplace Urban Realm (1964) also moves towards the notion of a vaporization of the traditional meaning of "city" to be substituted by networks of relationships at varying distances, in other words he's anticipating what will be later labeled by Antonio Font as "the explosion of the city"(2004). In all these contributions is present the concept of which Françoise Choay was one of the most illuminating authors: the idea that there was a transition happening "from the city to the urban" (1994). As Choay points out, this change of paradigm from the city to the urban, does not only imply a change of scale, but it effectively introduces a new urban order.

It is of general consensus that the transformation of metropolitan territories into dispersed, diffused territories occurred through the overlapping of three morphological growth types: the "peri-urbanization" (a progressive expansion of the outer fringes of the urban system associated with a shrinking of the central nuclei), the "urban diffusion" (the decentralization of urban activities and values over a wide area) and "rurbanization" (an organic growth of mixed urban and rural tissues from preexisting rural structures). We will analyze these three types of growth in the next paragraphs.

1.6 The history of the peri-urban interface concept

The present research, aiming at giving a contribution to the definition of place-based development strategies for extensive territories in Portugal, *de facto* deals with regions that are considered either peri-urban, or rurbanized or extensively urbanized. All of these different concepts will be described and discussed here for a correct framing in the theoretical debate as well as giving a background of the history of the concept. The term urban fringe was initially used by American geographers during the 1940s (Andrews, 1942; Myers & Beegle, 1947; Wehrwein, 1942) to describe an area where suburban growth was taking place and where urban and rural land uses mixed together formed a transitional zone between city and countryside. In those decades, in fact, a new population was invading local communities, bringing a new type of lifestyle, associated with dispersed living.

In the first studies about the urban fringe, a morphological and functional approach privileged the analysis of features such as density, morphology and land uses. Such approach implied a view of the phenomenon as an irradiating pattern from the urban center. On the other hand, human and rural geographers argued that the transitional landscapes between city and countryside were not necessarily the result of urban-driven processes, thus coining terms like rurban or rural-urban.

Soon it became evident that the urban fringe was set to originate intricate discussions about its physical and conceptual boundaries. Pahl, for example, with his *Urbs in Rure* (1965) defined the peri-urban fringe as being the result of particular social processes, mainly the migration of mobile middle class families oriented to the city and dominated by urban life styles. On the other hand Pryor (1968) introduced a new categorization based on the analysis of different phases of urbanization according to land use composition. Such categorization served to differentiate peri-urban areas from the rurban periphery.

These two approaches, one being based on the study of land use and morphological patterns and one based on the study of social dynamics that shape the transition between city and coutryside, have since then been present in the debate about peri-urban interface, being at time substituted by or articulated into new definitions. As an example of the first approach, Scott and Carter (2012) proposed a definition of the rural-urban fringe as the space into which the town extends to the outside as processes of dispersion operate. Carter however added a social variable in his approach, stating that such areas have distinctive characteristics which are only partly assimilated into the growing urban complex. These areas are therefore still partly rural; many of their residents live in the country but are not socially and economically linked to it.

Since the 1960s, however, the urban-rural dichotomy could not be maintained against the emergence of the rural-urban continuum. In truth, the city has been less and less seen as a discrete local place and the urban experience became, in some sense, universal. The basic urban functions have been transferred from a central city, first to suburbs, and then to the still larger decentralised “urban field” where the mobile middle classes – also thanks to huge leaps forward in mobility – have built a highly dispersed pattern of activities developing not on a place, but on a region – in what Melvin Webber called “nonplace urban realm”: an urban realm that was neither urban settlement nor territory. (Webber, 1964)

More recently and within the framework of the current discussions on global trade and production, a new terminology has emerged, characterised by the shift from the compact city/suburban dualistic patterns to the spread metropolitan and from mono-centric cities to multi-centred urban areas (Hall, 1996)

1.7 The concepts of peri-urban interface in Europe

The aforementioned shift to the conceptualisation of rural-urban interaction had also its effect in Europe. In France, for example, the term *périurbanisation* is used to describe a zone external to the city that surrounds it and that is discontinuous from the urban tissue, usually a result of a process of outward residential dispersal. In addition, the term rurbanisation, introduced in the 1970s (Bauer and Roux, 1976), has the added meaning, in the French regional planning milieu, of a “dissemination” of the urban on the rural, characterized by middle class lifestyle and ideology.

All around Europe, the debate over new forms of landscape that resulted from the spread of urban functions and urban lifestyles across an extended territory gave rise to a set of new concepts like the métapolis (Ascher, 1995a), *ville éparpillée (Bauer & Roux, 1976)*, *ville archipel* (Viard, 1994) in France; or the concept of *ciudad dispersa* (Monclús, Dematteis, et al., 1998) in Spain and Portugal; or *Zwischenstadt* (Sieverts, 1998) in Germany or the term *città diffusa* (Indovina et al., 1990) coined in Italy. The transition to these new landscapes is challenging the theoretical discussion and the professional practice of planning across Europe, raising questions about the necessary adaptation of the urban and regional planning set of conceptual and practical tools to cope with the new territorial reality across Europe.

In such conceptual field, it is important to notice that much relevance is still given to the concept of the peri-urban interface, considered as a transitional zone between the city and the countryside, while less importance is given to the concept of extensive urbanization – or as Alvaro Domingues calls it, the transgenic landscapes (2013). Unfortunately, European policies aiming to foster territorial cohesion still consider the existence of either rural or urban situations, while the reality of many regions of Europe suggests that the boundaries between these two conditions are turning increasingly blurred (Tacoli, 1998). It is therefore of paramount importance to establish a conceptual and methodological framework capable of dealing with the reality of extensive urbaniation, as a novel condition distinguished from both the "urban" and the "rural".

1.8 The Portuguese context

After the end of World War II there has been an exponential increase in the growth rate of European cities. In many countries, such as in France or Great Britain, this demographic growth was accompanied by urban expansion policies, creating new urban agglomerations and even exploring new typologies like the New Towns or the Grand Ensembles (Aldridge, 2017).

Such demographic growth did not have get the same political response in Lisbon, therefore, given the lack and the rising demand of housing (also exacerbated by the decolonization and the migration from Portugal's rural interior) and the lack of any public plan to create more housing opportunities around Lisbon, countless large clandestine neighborhoods of illegal genesis (AUGI) were built in a few decades in those spaces that were left empty by the consolidated town - from Reboleira (in Amadora) to Santo António de Cavaleiros (Loures), to Casal de Cambra bordering Sintra's municipality.

In the specific case of Lisbon, recent studies on changing mobility - "Da cidade pedestre à metrópole do automóvel" (J. P. S. Nunes, 2009) – on changing demography "Dos subúrbios citadinos aos subúrbios metropolitanos" (João Pedro Silva Nunes, 2010) - on the shape of the suburbs adjacent to Lisbon - "Formas de Habitat Suburbano. Tipologias e Modelos Residenciais na Área Metropolitana de Lisboa" (C. Cavaco, 2009)- on road infrastructure as a conducting line of "transgenic territories" - "A rua da estrada"

(Domingues 2012) - have brought to the discussion around the diffused territories of the peripheries a great deal of new information that allows us to begin to understand these same territories, not as a imperceptible blob that exists around a city but like places with their own specificities and with their own history and urban development and above all turning them into legible territories.

1.9 Rurbanization versus transgenic landscapes

As Alvaro Domingues explains: "The widest consensus around the diversity of contexts used to define the extensive urbanization, is that it represents a new way of conceiving the dichotomy city/countryside or urban/rural."[4] (2008, p. 6)

In fact, the link between the city and the countryside has evolved very rapidly in the last decades, shifting away from the assumptions of mainstream paradigms to new conceptual landscapes where rural-urban links are being redefined.

Already in the seventies, as we have seen, Gérard Bauer and Jean-Michel Roux in their publication "La rurbanisation; ou, La ville éparpillée" (1976) pointed out at the emergence of a new phenomenon – rather ignored at that time in France – of expansion of the city into a rather dispersed territory. Using a this neologism, "rurbanisation", they identified the uncontrolled extension of the cities across the rural areas surrounding them. The process already generally present in France at that time, but largely ignored by the public administration and the French planners, was for the first time named and described in their book. The accelerated rate of urbanization, the modernization of agriculture, the invasion of the countryside by industries and the transportation networks dissolve the borders between urban and rural. Rather than a strictly physical phenomenon, this is a process of socioeconomic development that combines urban and rural values and lifestyles. However, those rurban areas that arise from such phenomenon are always difficult to define and are bound with problems inherent to the definition of both rural and urban worlds. A sharp distinction between urban and rural conditions generally assumes that the livelihoods or the inhabitants can equally be

[4] "O maior consenso em torno da diversidade de contextos usados para denominar a urbanização extensiva, é o que ela representa uma forma diferente de pensar a dicotomia cidade/campo ou urbano/rural."

reduced to two main categories: agriculture in rural areas and manufacture and services in the urban centers (Tacoli, 1998).

Indeed, in many regions of the world the boundaries between urban and rural are getting increasingly blurred, thus affecting the very definition of the rural-urban interface. Recent developments both in theory and in real world contexts – such as space-time compression, international trade and economic globalization — point to the need of a reassessment of the nature of the rural-urban divide, where not only flows of people, but of capital, labor, commodities and information leave the urban centers for a place-less extensive territory (Sassen, 1988). In fact, it is generally accepted that while the globalization processes tend to "de-emphasize" place, a "paradigm shift" here seems ready to emerge, where places become more and more generic yet they started to compete with each other on a global scale. Space is not isotropic but the truth is that the necessary factors and infrastructures to the organization of production can be located in highly variable contexts.

1.10 The concept of *città diffusa*

The study of recent territorial transformations in the urban regions of Europe highlights the emergence of different forms of dispersed urbanization. These novel forms of urbanization can be more or less discontinuous with respect to the existing settlements however they are all linked by a common trait: the dispersal of traditionally urban functions into an undefined extensive territory. Such phenomenon has been labelled, in the Italian urban and regional studies context, *città diffusa* – or diffuse city.

It is a widely accepted notion, in fact, that the traditional city is dissolving. The contemporary processes of extensive urbanisation created new landscapes that differ radically from the traditional city. However, such dynamic does not imply the demise of the urban condition and urban culture: the urban condition is not only surviving, but thriving and renewing itself. What is new in such scenario is that the urban condition started to arise in places that lacked the traditional physical and morphological attributes of a city. On one hand, the flows of people and economic activities into rural areas, and the acquisition of urban lifestyles by people settled in the countryside on the other hand, gave birth to a new kind of urbanization. This is not a refusal of the city, it is an adaptation of new territorial configurations made to accommodate changes in social organization.

While the concept of *città diffusa* may seem a paradox due to its contradictory meaning, it is important here discriminating between urban morphology and the urban condition. The fundamentals of a city are in fact urban morphology, i.e. its physical appearance and form; and the urban condition, i.e. the kind of social, economic and cultural relations typical of city life. The kind of shift that the diffuse city introduced is that it allowed for the development of a urban condition outside the traditional city walls. Thus, people living in the diffuse city can receive the benefits of agglomeration without agglomerating.

Such extensive city is characterized by several new epicenters external to the city center that form a meshwork of functional centralities (e.g. malls, outlets, new areas of business and leisure) (Fregolent, 2012).

This novel space resembles the theories of non-place urban realm by Melvin Webber, testifying that it is not the walls (or a given shape, or a given density) that make a city, but the relations between people, their lifestyle and activities that make the (diffuse) city. The concentrated city is not disappearing, but it is no longer the only one form that ensures the urban condition.

Traditionally, the concentrated city of large or medium scale tended to catalyze most of the governmental institutions (political, administrative, financial, cultural, educational, etc.) as well as it centers of excellence (research, higher education, etc.). In this process of diffusion, the *città dispersa* attracted many of the opportunities that have been created by the globalization and the contemporary models of decentralized production and global trade. The concentrated city has attempted to defend its role of driving force in such context, but those novel dynamics were mostly non compatible with its closeness and its resistance to change.

In fact, kind of city that gradually emerged first in North America and then Europe in the 20th century is a low-density city, hyperextended, difficult to be served by a public transport system and therefore car-dependent. Francesco Indovina, however, draws a clear distinction here between the American urban sprawl and the explosion of the city that affects the European towns: what differentiates these two paradigms of dispersed urbanization is the driving force behind it.

While U.S. suburban sprawl is a process of intervention for major aggregates, blocks of houses, etc., the European urban dispersion is a phenomenon which in large part is generated by single choices of people or businesses moving toward the urban fringe and rural areas. One is a top-down urbanization process while the other is a bottom-up process or the sum of individual choices.

The North American suburban sprawl is a way to conceive and build the city, while the concept of "urban diffusion" – as Indovina calls the European process – is a mode to modify an established urban situation. The results of these two paradigms are completely different: the European processes of urban dispersion encompass and incorporates traditional settlements establishing new centralities with strong links to the traditional city centers, while the processes of suburban sprawl in the USA translates into building a completely new landscape (Indovina et al., 2009).

We've seen here how the debate around new concepts of contemporary city has been approached by different theorists. Whatever the results of this debate may be, the challenge for the contemporary city, whether it be historical or dispersed, remains: it is of paramount importance to create now a consistent framework of novel concepts, methods and tools capable of dealing with the dynamics and dimensions of the contemporary urban phenomenon.

2. On urban form, sustainable development and territorial capital

2.1 Urban form versus contemporary urban condition

Historically the physical city has been regarded has one with urban condition. In fact, the contemporary city does not translate this solidarity anymore. The contemporary city is too plural, it assembles too many forms and fabrics, as logical as they are disconnected and fragmented, too many forces and vectors that it becomes impossible to establish a direct relation between the form of the city and its political organization, or between the form of the city and its mode of use. As Álvaro Domingues explains, traditionally *urbs* (the city as physical artefact) with *civitas* (the city's social organization) and the *polis* (the city as a political space) formed one single entity characterized by an inextricable physical, political and social configuration. (Alvaro Domingues, 2008)

The contemporary city transcends this unity by creating a separation between urban form and urban condition. The notion that the traditional city is in many ways dissolving has become commonplace today. In many respects, the judgement is indisputable. (Indovina et al., 2009) The contemporary process of urbanisation has created spaces that differ radically from the cities of any other historical period. That said, the phrase "dissolution of traditional cities" cannot allude to the demise of the urban condition which is well and thriving but rather to a stereotypical idea of the city and its morphological setup.

Such concept, of the chiasm between urban form and urban condition, is at the very core of the concept of Città Diffusa by Francesco Indovina. As he argues: *“La città non è una forma o una struttura fisica ma è relazioni sociali, rapporti sociali di reciprocità tra chi l’abita, lavoro, ricerca, commerci, divertimenti, e quanto gli uomini e le donne che la popolano sono capaci di fare e di inventarsi per la loro vita. Non che la forma urbana sia indifferente e non conti, ma si vuole sottolineare come una “città” segnata*

dall'assenza dell'uomo, costituisce un sito archeologico, qualcosa che è stata città e non lo è più proprio per quell'assenza. Tutto questo è noto e banale, eppure, quando ragioniamo di città, si tende a dimenticare questo dato, si suole dare massima importanza alla forma e non alla sua vita." "[5] (2009, p. 19)

The fundamental components of a city are: urban morphology - its physical appearance and form - and the urban condition - the kind of social, economic and cultural relations that living in a city makes possible. As Indovina defends "granted that the urban morphology has been disrupted, the urban condition is persisting, thriving and developing, albeit in extremely different settings, and is increasingly becoming the heritage and experience of an ever-growing number of women and men.". (Indovina, 2016, p. 93)

So, as the urban as a social condition become more and more detached from the city as a physical entity a whole range of new possibilities and of new issues arise. Is the role of urban form still relevant in determining if a city functions in an efficient way or not? Is the process in planning more relevant than the actual forms of the plan? Is there an optimal model for territorial occupation? Compact city? Polycentrism? Or the forms and models of occupation don't even matter anymore? We will try to answer all these questions in the following paragraphs.

2.2 Information space

During the last decade of the 20th century, with the rapid introduction of the Internet, there was a common belief that physical space would be stripped of its significance by a ubiquitous "information space". The Internet suddenly was seen as an instantaneous and spatially-indiscriminate connective tissue. Many theorist predicted a future when "distance is irrelevant" (Cairncross, 1997) as people would be "cut loose from fixed locations" (Mitchell, 1996) by a global "infobahn" bringing with it a "Global Village"

[5] "The city is not a form or a physical structure but it is social relations, social links of reciprocity between those who live in it, work, research, do business, entertainment, and as men and women who inhabit it are capable of doing and of inventing for their life. Not that the urban form is indifferent and does not account for but I want to emphasize that a "city" marked by the absence of men, it is an archaeological site, something that was a city and no longer is - precisely for that absence. All this is known and banal, and yet, when we reason of the city, we tend to forget this fact, it is common to give maximum attention to the form and not to his life" (Translation mine)

condition – as already predicted by Marshall McLuhan (McLuhan, 1962). Cairncross elaborated an economic, social, and civic argument advocating "a world in which transmitting information costs almost nothing, in which distance is irrelevant, and in which any amount of content is instantly accessible" (1997). The underlying idea was that dense urban space – formerly the key element of human interactions – would become useless in the Internet age, as information could be sent and received ubiquitously and instantaneously.

Interestingly, now we know that the information age did not kill cities, but neither did it leave them unaffected. As we have seen many phenomena altered the link between the physical city and the urban condition. In fact, as Ratti and Claudel underline "far from the predicted corrosive effect of networks, the dynamic virtual overlay is augmenting and redefining physical space today. Cities have not withered, but in fact emerged as a vital complement to virtual activity – perhaps more important than ever before. As its digital and material dimensions continue to merge and blur, urban space becomes the crucible for actions and re-actions between bits and atoms, all to the benefit of human experience. This is the genesis of the *smart city*: urban space reinforced, reinvented and reinvigorated by a virtual dimension." (Claudel & Ratti, 2016, p. 5)

For this reason, in our research we gave the utmost value to the issue of localization, being our fundamental belief that localization still is one of the key factors that influence the success of a region or of an economic endeavor of whatever nature.

2.3 Conceptualizing sustainable development

Since the late 1980s, sustainable development has attracted much interest from government agencies, businesses, nongovernment organizations, and civic groups, resulting in an increasing number of policy initiatives in both the public and private sector. Yet, as the concept of sustainable development gains more and more popularity, still some people and organizations that cite sustainable development as one of their main objectives often lack a firm grasp of the true meaning of the concept. Such an understanding is important as it provides a holistic perspective on development against which a sectoral focus on sustainability can be considered.

Some early critiques on the concept of sustainable development revealed a wide range of interpretations and a lack of a sufficiently robust theoretical and analytic framework against which decisions aimed at achieving a more sustainable form of development could be assessed (Norgaard, 1988; Holmberg & Sandbrook, 1992) . Such reviews indicated that sustainability should be seen as a broad field of inquiry encompassing issues of cultural integrity, justice, and governance, as well as questions of ecological concerns to economic activity and the national right to economic development.

In fact,the different ways in which sustainable development can be formulated raises challenges to its operationalization and measurement: questions like what is to be sustained, for how long, and who bears the costs? are common concerns.

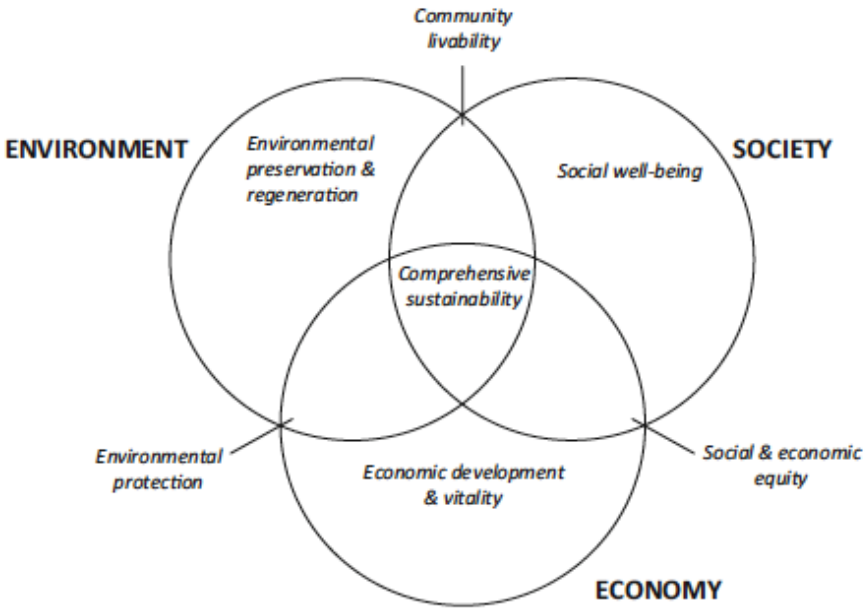

Figure 1 - Comprehensive sustainable development. Sources: (Brodmann & Spillmann, 2000)

The figure above provides a common representation of sustainable development that is often associated with the model of development popularized by the Brundtland Report. This diagram simply implies that progress in all three of the environmental, social, and economic dimensions is necessary in order to achieve sustainable development.

Over the years different scientific disciplines framed the concepts of sustainable development quite differently between each other, giving birth to different notions of sustainability. On one side, weak sustainability (Solow, 1993) in which the natural capital is thought to be fungible by human-made capital and strong sustainability (Daly, 1991) on the other side, stating that many of the most fundamental services provided by nature cannot be replaced by services produced by humans or man-made capital.

In summary, the basic distinction between "weak" and "strong" sustainability has fundamental implications as to whether environmental systems and natural resources should be kept intact or if the environment can be exploited as long as the overall value of society's economic capital is kept intact.

In the present work we decided to maintain a framework that is synthetized by the following principles that have emerged from the sustainability literature and reflect the recent international perspective of sustainable development.

Sustainability therefore entails meeting human needs for the present and future, while:

- Preserving environmental and ecological systems
- Improving quality of life
- Promoting economic development that includes the creation of meaningful and well-paid jobs
- Ensuring equity between and among population groups and over generations

As we will see later, such principles are also in line with the main guidelines of Sintra's strategic planning for the next decades.

2.4 The importance of a quantitative and holistic approach to sustainable development

The term development entails a continual process of change. Sustainable development,

therefore, describes a process of change that promotes the principles of sustainability as previously described. The only way of knowing whether progress is being made toward sustainable development is to measure and monitor performance, considering different development scenarios/strategies through time.

This process requires the use of indicators to quantify the key parameters that define

sustainable development. Thus, indicators are paramount to any attempt to implement a sustainable development agenda. The current discourse on indicators of sustainable development is driven by the fact that different knowledge domains (such as economics, density studies, network analysis, sociology) view sustainable development and its indicators differently making the task of defining, measuring, and responding to perceived problems highly complex.

It is a fundamental assumption of this thesis that the sustainable development requires a holistic and integrative approach both to the analysis of its indicators and to the design of policies and initiatives for its achievement. In order to capture the broad array of the variable that regulates it, environmental, social, and economic features need to be considered. Dernbach (2003, p. 250) adds that "integrated decision-making is the foundational principle of sustainable development. Thus, sustainable development requires that fragmentation in decision-making be eliminated."

An integrative, holistic and trans-disciplinary approach is also required to overcome the fragmentation of the knowledge base that leads to the creation of single purpose or narrowly fashioned solutions to complex problems.

2.5 The role of urban form in sustainable development

As we have seen, there are numerous definitions of the term "sustainable development". Alongside conservation of natural resources and energy consumption reduction, sustainable economic development is a priority of compact cities. The OECD's Green Growth Strategy defines green growth as "fostering economic growth and development while ensuring that natural assets continue to provide the resources and the environmental services on which our well-being relies" (OECD, 2011, p. 4).

According to the 1992 Earth Summit in Rio de Janeiro, "sustainable development" is defined as a "development which meets present needs without compromising the ability of future generations to achieve their needs and aspirations" (Burton, Jenks, &

Williams, 2003). Such definition widened the scope of the concept far beyond the more restrictive environmental perspective and put the emphasis on the principles of intra and intergenerational solidarity. In fact sustainable development must be understood as continuum in time rather than a single-moment snapshot. That's why besides being a spatial configuration characterized by "compactness", compact city model is a development paradigm that aims at fostering growth and well-being within the urban context over time, by keeping the urban footprint and the overall social and environmental costs as low as possible and by triggering and sustaining intergenerational solidarity dynamics. Compact city policies are in turn understood as a comprehensive approach to achieve compact city performances by influencing the ways development strategies are conceived, territorial policies are implemented and urban space is utilized.

The last decades have brought critical changes in the spatial organization of cities. Different phenomena such as urban sprawl and leapfrog unplanned developments radically modified demographics, population density, economic and social structures but also – and sometimes very dramatically – the form of cities. Compact urban settlements have been taken as an immediate response against the problem of urban sprawl. Such sprawling phenomena have been pointed out since the last decades of the 20th century as one of the most decisive menaces to sustainable development, because of the high impacts on energy inputs, land consumption and soil sealing – to cite a few reasons. As the discussion around the topic of sustainable growth increasingly emerged – especially after the release of the Brundtland Report (Keeble, 1988) – the benefits of a compact urban development for a sustainable urban form became a wide-spread mantra in the search for simplistic solutions to the issue sustainable development and the return to a compact city model arose and grew up as a natural reaction, running counter to urban sprawl. The compact city thus became one of the most discussed concepts in contemporary urban policies but much attention has been put into the relationship between urban form and sustainability.

In fact, most authors looked at the compact city model from a purely morphological perspective oversimplifying the relationship between urban form and sustainability and proposing the compact city model as a sort of sponge-like concept capable to tackle all the issues posed by urban sprawl (Elkin, McLaren, & Hillman, 1991; Jenks et al., 1996; OECD, 2012b; Power & Rogers, 2000).

Yosef Rafeq Jabareen in his study identifies (2006) four sustainable urban forms. The different form types are compatible and not mutually exclusive. However, there are some distinctive concepts and key differences for each one of these forms, as follows:

1. Compact city – the distinctive characters of the compact city are high density and compactness. It proposes mixed land uses like the approaches of new urbanism or neotraditional development.
2. The eco-city – it emphasizes urban greening, ecological and cultural diversity, environmental management and other key environmentally sound policies.

3. Neotraditional development – it emphasizes sustainable transportation, diversity urban fabric, compactness, mixed land uses, and greening. In addition, neotraditional development has much to do with style and design coding (Katz, Scully, & Bressi, 1994).
4. Urban containment – it just emphasizes policies of compactness.

Compact city rises from this range of sustainable urban forms as the one that enjoyed a more mainstream success and diffusion. It is the model that many talk about when talking about sustainability. However, several criticisms to the compact city concept coalesced into what has been called "the compact city fallacy" (Neuman, 2005) all arguing against the abusive position that considers the compact city as a sort of panacea for the problems of extensive urban developments. Following Neuman, urban form is not a sufficient condition to drive urban sustainability: "conceiving the city in terms of form is neither necessary nor sufficient to achieve the goals ascribed to the compact city. Instead, conceiving the city in terms of process holds more promise in attaining the elusive goal of a sustainable city" (2005, p. 11). Process is more critical than form when it comes to deliver sustainability.

2.6 The compact city paradigm

The compact city concept, as first coined by George Dantzig and Thomas Saaty, was focused on putting forward a more efficient city model on the use of space and resources. The original formulation of the concept presented a visionary circular city composed by different levels and platforms where activities were distributed in a vertical way (1973).

Apart from the formal configuration of the proposed model, the compact city of Dantzig and Saaty showed crucial urban sustainability features like diversity and mixed land. Many of such principles traced back already to Jane Jacobs's book "The death and life of great American cities" (Jacobs, 1961). Jacobs proposed diversity as a reference concept on upholding livability and quality of life in cities. In opposition to modern urban zoning, Jacobs proposed mixed-use neighborhoods and streets, short blocks layouts, building variety and density: for her this are the crucial features at the foundation of a vital and diverse character of a city.

As Richard Rogers affirms (2000), the compact city can be a valid paradigm for a more sustainable form of urbanism. He defends this position by arguing that the fundamental benefit of the compact approach is that the countryside is protected from the encroachment of urban development, while the city grows in a compact manner around a number of centers of social and commercial activity. The idea is that proximity of labor, living and leisure would lower the dependency to transportation turning the city more environmentally sustainable.

However, a direct relationship between urban sustainability and compactness can hardly be drawn. As Burton, Williams and Jenks recognize "the problem of how the compact city can deliver sustainability is complex; it depends on the relationship between the form and location of intensification, the extent of intensification, and the policy, management and wider socio-political and economic context." (2003, p. 8). For this reason caution must be exercised in assigning causal effects from the compact city.

An extensive literature deals with the definition of compact city. Although cities differ between one another, it is possible to consider that the key morphological characteristics of a compact city are:

- Dense and proximate development patterns. Density involves how intensively urban land is utilised, and proximity particularly concerns the location of urban agglomerations in a metropolitan area. In a compact city, urban land is intensively utilised, urban agglomerations are contiguous or close together and the border between urban and rural land use at the urban fringe is clear. However, public spaces including squares, streets and parks are also essential elements. Density and proximity are two major physical (or morphological) elements of the compact city.
- Urban areas connected by public transport systems**.** These indicate how effectively urban land is utilised. Public transport systems facilitate mobility in urban areas and enable urban areas to function effectively.
- Accessibility to services and jobs. This concerns how easily residents can reach local services such as grocery stores, restaurants and clinics as well as neighbourhood jobs. In a compact city, land use is mixed and most residents have access to these services either on foot or using public transport.

2.6.1 The primacy of process over form

Surely formal aspects alone don't capture the complexity of the problem of sustainable development. When it comes to sustainability process – rather than forms - contributes greatly in shaping the outcome for a territory. Michael Neuman in his The Compact City Fallacy advocates the primacy of process over form. It is the urban processes themselves that might be sustainable, not urban form, he says. "Form is a snapshot of process. It is a fixed condition at any point in time" (Neuman, 2005, p. 13) so it is by no means measurable in terms of sustainability.

Unfortunately, during the last decades much attention has been put into the relationship between urban form and sustainability (and not between the process of planning and sustainability – as we defend in this work). Above all, the main purpose has been achieving alternative solutions and adequate planning strategies to contain urban expansion and protect open land and natural resources. The problem is that these goals were often tackled by proposing a formal solution. Elkin et al. (1991) and Mike Jenks et al. are the scholars that among the others have contributed the most to ascertain a close

correlation between urban form and sustainability, questioning to which extent the form of cities affects a sustainable urban development. But again as Neuman stressed out "the relation between compactness and sustainability can be negatively correlated, weakly related, or correlated in limited ways" (2005, p. 2). In fact, a direct relationship between urban sustainability and compactness can hardly be drawn. He then remarks that "the attempt to make cities more sustainable only by using urban form strategies is counterproductive" (2005, p. 13).

2.6.2 The need for an integrated approach

Cities need to break away from compartmentalized approaches and to integrate formerly fragmented policy actions by taking into account the spatial, economic and social dimensions of urban development; an approach that will help them to achieve a better territorial cohesion. Multilevel urban governance has been advanced as the government model that meets most of the requirements needed. This mostly because it can be defined as an arrangement for making binding decisions that engages a multiplicity of politically independent but otherwise interdependent actors – private and public – at different levels of territorial aggregation in more-or-less continuous cycle of negotiation, deliberation and implementation.

Also, the challenges posed by the contemporary territories imply that there is a clear need nowadays to include the concept of territorial capital into any territorial planning effort and its importance for spatial planning and cohesion. In essence, what is at stake is precisely the convergence that has been taking place over the last two decades between spatial planning itself and regional development (there is indeed an ever-growing talk of territorial development linking the two dimensions). This tendency towards intersection, overlapping between the two areas has also been associated with a tendency for the spatial planning to gain a more strategic dimension and to be associated and intertwined with territorial governance.

In this work our mother perspective is the one of spatial planning, so that means that we will leave for future works and external contributions concerns and discussions about the governance side of the work. It is important to note however that the framework and the operative model proposed in this work can also be used to monitor results and inform decision-making processes for governance.

2.7 The choice of territorial capital

The present work is based on the concept of territorial capital and it is focused on the definition of a framework of indicators that can translate the concept of territorial capital into practice, keeping in mind the availability of relevant data and the strategic priorities of Sintra's municipal planning. The adoption of the policy objective of territorial cohesion at the EU-level has sparked interest in "territorial capital" which, according the Camagni and Capello (2013) encompasses a wide variety of territorial assets, both tangible and intangible, of a private, public or mixed nature.

As the Spatial Development Glossary, elaborated in the framework of the Council of Europe Conference of Ministers responsible for Spatial/Regional Planning (CEMAT), calls it territorial potential and citing the OECD Territorial Outlook says:

It has been recognised that each area has a specific potential (or capital) which is distinct from that of other areas and which is determined by a series of factors which may include the area's geographical location, size, endowment with factors of production and infrastructures, climate, natural resources, quality of life and of the environment or the agglomeration economies provided by its cities, the business incubators, industrial districts or other business network which reduce transaction cost. Other components are of more social and cultural nature, comprising factors such as traditions, understandings, informal rules that enable economic actors to work together under conditions of uncertainty, solidarity, mutual assistance. The concept of territorial potential comprises also a more intangible dimension related to the outcome of a combination of institutions, rules, practices, actors such as producers, researchers and policy makers that make a certain creativity and innovation possible" (2001, p. 15)

The CEMAT glossary then goes on by point at the historical reasons that made this concept appear in the first place and why it is important now to reclaim it as a fundamental framework for tackling today's territorial issues of the European Union: "The concept of territorial potential (or capital) is underlying the endogenous growth theories and strategies which have been developed and applied since the 1970s as a reaction against the instability or negative impacts of exogenous factors causing unemployment, closing down or relocation of businesses. In recent years, the concept of territorial potential has become topical again because of increasing international and interregional competition in the context of European integration and accelerating globalisation" (2007).

One of the main aims of this work is to demonstrate the role of some endogenous factors in explaining the differentiation of regional growth patterns and the different vocations of each specific location in the territory. The territorial capital is, in fact, usually defined as the system of territorial assets of different nature (from economic, to cultural, social or environmental) that ensures the development potential of a place. In a general definition, territorial capital may be seen as the set of localized assets – of natural, human, artificial, organizational, relational and cognitive nature – that constitute the competitive potential of a given territory (Camagni & Capello, 2013). The strength of such concept resides in the recognition of possible interactions between factors of different nature. So far, however, very few studies have focused on the empirical verification of the links between territorial capital and economic growth.

2.8 Endogenous regional growth

Regions are strategic workhorses in a competitive economy. And they are – in a globalizing and open economic world – increasingly seen as magnets of economic growth and innovation. The fundamental assumption that permeates this work is that

physical space and location are central variables in explaining regional development, along with their "human" capital.

The need for anticipatory policies has always induced to seek reliable methodologies able to produce insights on what the future will look like, with constant attempts to increase the interpretative power of theoretical models. This is the way how the area of regional economy took form.

Reflection on the role of intangible assets as well as material ones, and the account for a more active role of space in explaining regional development dynamics – superseding the mere geographical interpretation of space – are good examples of the attempts made over the course of the last decades to innovate and foster the theories of regional growth.

The concept territorial capital was first proposed in a regional policy context by the OECD in its Territorial Outlook, as we have seen, and it has been recently reiterated by DG Regio of the Commission of the European Union: "Each Region has a specific 'territorial capital' that is distinct from that of other areas and generates a higher return for specific kinds of investments than for others, since these are better suited to the area and use its assets and potential more effectively. Territorial development policies (policies with a territorial approach to development) should first and foremost help areas to develop their territorial capital" (CEC, 2005, p. 1).

The OECD has drawn up a long list of factors considered as the determinants of territorial capital: ranging from traditional material assets to more recent immaterial ones - "the area's geographical location, size, factor of production endowment, climate, traditions, natural resources, quality of life or the agglomeration economies provided by its cities, but may also include its business incubators and industrial districts or other business networks that reduce transaction costs. Other factors may be 'untraded interdependencies' such as understandings, customs and informal rules that enable economic actors to work together under conditions of uncertainty, or the solidarity, mutual assistance and co-opting of ideas that often develop in clusters of small and medium-sized enterprises working in the same sector (social capital). Lastly, according to Marshall, there is an intangible factor,'something in the air', called the 'environment' and which is the outcome of a combination of institutions, rules, practices, producers, researchers and policy makers that make a certain creativity and innovation possible" (OECD, 2001, p. 15).

Given these premises, it is easy to see why the new concept of territorial capital deserves closer inspection, as a novel regional growth theory it differs from traditional because of the role of space and location.

As Roberta Capello explains "Historically, regional growth theories have viewed regions as areas of limited physical-geographical size (largely corresponding to administrative units) considered to be internally uniform and therefore described by a vector of aggregate characteristics of a socio-economic-demographic nature: 'small countries' in the terminology of international trade but, unlike nations, characterized by

marked external openness to the movement of goods and production factors. The advantage of this conception of space was that it enabled the use of macroeconomic models to interpret local growth phenomena under the assumption of constant returns to scale. But this assumption inexorably excludes any mechanism of agglomeration, discards location theory and ignores the advantages of local proximity. Space is thus no more than the physical container of development and performs a purely passive role in economic growth, while some macroeconomic theories reduce regional development to the simple regional allocation of aggregate national development." (Cavaco et al., 2015, p. 79).

One of the expressions of this renovated look at the territorial question is represented by the Smart Specialisation Strategies (RIS3 or S3). These set priorities at national and regional level to build competitive advantage by developing and matching research and innovation own strengths with business needs, to address emerging opportunities and market developments in a coherent manner, while avoiding duplication and fragmentation of efforts. They are also a backbone of national or regional research and innovation strategic policy frameworks in Europe.

2.9 The concept of territorial capital

Although the concept of territorial capital occurred in several scientific essays and documents of the European Union since 2001 (OECD, 2001), these publications, apart from mentioning the expression, have not given any exact definition of the concept. As the theory was newly shaped and the expression "territorial capital" lead to many different interpretations at the beginning. But out of these approaches the

concept of Roberto Camagni, published in 2008 (Capello et al., 2008), seems to be a generally accepted and wide-spread concept in regional sciences nowadays.

Urban systems should ideally be modeled on the capacity of their nodes to generate external economies. That is, settlements should grow and develop as long as they have the capacity to generate those economies, and as congestion costs begin to surface, growth should move to another point in the territory where they would naturally arise again . The logic inherent to this argument is based on the strengthening of the urban versus rural, as the former acts as a catalyst for the outer space economies, for its compact, dense, multifunctional and complex configuration, its morphology continues and its availability of capital physical and social. The modeling of this ideal pattern of growth of settlement systems is not possible without a systematized regional planning process that orders the expansion and reorganization of population and productive activity.

As Camagni and Capello (2013) correctly pointed out:

"'Territory' is a better term than (abstract) 'space' or (internally homogeneous) 'region' when the following constituent elements are considered:

- A system of localized externalities, both pecuniary (where their advantages are appropriated through market transactions) and technological (when advantages are exploited by simple proximity to the source).
- A system of localized production activities, traditions, skills and know-how.
- A system of localized proximity relationships which constitutes a 'capital' – of a social psychological and political nature – in that it enhances the static and dynamic productivity of local factors.
- A system of cultural elements and values which attribute sense and meaning to local practices and structures and define local identities; they acquire an economic value whenever they can either be transformed into marketable products – goods, services and assets – or can boost the internal capacity to exploit local potentials.
- A system of rules and practices defining a local governance model.

All the above elements, of a non-material, cognitive and relational kind – which add to, and do not substitute for, more traditional, material and functional elements – may be encompassed and summarized by a concept hat, strangely enough, has only recently made its appearance, and outside a strictly scientific context: the concept of territorial capital."

2.10 The territorial capital in the Territorial Agenda of the European Union 2020

The Territorial Agenda of the European Union 2020 is the key political ambition of the Union in terms of territorial governance. The goal expressed to achieve a better territorial cohesion that could help each region to express its territorial capital in most successful way, creating sustainable economic growth with greater social cohesion. The territorial dimension is essential for the implementation of any European economic strategy as most important and dynamic forces in terms of economic development are increasingly both localised and territorially specific.

One of the key challenges in this respect is the accelerated relocation of economic activities. Factors underlying this trend include lower production costs and the rapid development of advanced technologies and significant markets in emerging economies. Global competition is not limited to enterprises – cities and regions compete with each other but also cooperate to attract economic activities. The competitors are increasingly territories in other countries. In this light, cities and regions specialise in certain kinds of production because of their specific territorial advantages. The most competitive are those that are able to respond most effectively to globalisation. Less competitive regions may suffer as a result of globalisation, leading to greater EU regional disparities.

To put it briefly, the Territorial Agenda of the European Union 2020 aims at strengthening the territorial capital of Europe's cities and regions. In policy terms a classification can be made:

- exploiting the endogenous potentials of an area: including natural and cultural values

- promoting an area's integration and connectivity to other areas that are important for its development
- territorial governance: promoting horizontal and vertical policy coherence.

Bottom-up initiatives and activities likely to strengthen synergy and coherence among the various sectors, such as territorial development strategies and policies are therefore important conditions for success. For this reason, once again we consider the topic of this work – and the debate it could trigger – of paramount importance for the current context of regional planning, especially from a perspective of reinforcement of centralities and urbanities that could on one hand contrast the extensive urbanization that characterize some sections of the Portuguese territory and on the other hand give rise to new agglomerations and possibly innovative *milieus*.

3. SINTRA'S CASE STUDY

3.1 Why a case study research?

A case study is a research strategy that investigates into a real-life phenomenon and involves an in-depth examination of a subject of study, aimed at gaining a better understanding of "how" and "why" things happen within its contextual conditions (Stake, 2005). Unlike in experiments in hard sciences, in the case study methodology the contextual conditions are not delineated or controlled, but are part of the investigation.

However, the case data – distilled from its contextual conditions - can lead to the identification of patterns and relationships, creating, extending, or testing a theory (Gomm, Hammersley, & Foster, 2000).

A clear definition of what case study means in different context comes from Creswell et al. (2007). The authors describe case study as "a methodology, a type of design in qualitative research, an object of study and a product of the inquiry". In the present work a case study has been employed as methodology, type of design research, object of study and a product of inquiry. The reason why in many social sciences – and in urban studies - the case study is a common approach in research methodology is that it represents a systematic way of looking at a bounded system. For bounded system we define one entity that has distinct limitations or a finite size and that for this very reason is susceptible to an exhaustive analysis. In the present work we selected the case study of Sintra's municipality territorial planning to test and discuss our hypothesis and our proposed strategic planning methodology.

The present chapter, by giving an overview on the subject of the work, will illustrate the choice of Sintra as case study as well as elucidate how we carried the process of study and analysis of Sintra's territory for the sake of a definition of development strategies for the re-urbanization of a sustainable extensive territory such as the one envisaged for Sintra. Through the chapter we will provide descriptive information about Sintra's case and illustrate its theoretical relevance in the context of Portuguese strategic planning designed to enhance the territorial capital of the region contrasting the tendency for urban dispersion, enabling an in-depth understanding of the case.

3.2 The choice of the case study

When selecting an appropriate case study to investigate the potential of a model capable of guiding in the process of formalizing development strategies for the re-urbanization in a context of extensive urbanization, we chose Sintra as the most adequate case to represent many of the dynamics of the coastal extensive urbanization that characterizes much Portugal's coast between Lisbon and Porto.

In fact, the whole coastal region that spans from Lisbon to Oporto presents traits of dispersed urbanization. Looking at the most relevant urban and population dynamics in Portugal, especially those that took place in the last two decades, we can see a significant reinforcement of the great movements of “urbanization”, “metropolization” and “coastalisation” as the document by the Direção Geral do Território Cidades Sustentáveis 2020 also points out. (C. Cavaco et al., 2015).

However, the conditions for urban dispersion in Portugal are not formed by the mere expansion of urban functions to the rural countryside. Unlike other examples in other countries, the dispersed urbanization that invests Portugal doesn’t take place in amorphous territories but instead in areas historically structured by basic urban or rural typologies and served by a primary network of roads and by basic infrastructures for energy, sanitation and water supply. In this basic structure, a territorial occupation is juxtaposed with a new occupation that reinforces the traditional socio-cultural composition, which is already rapidly changing due to the novel access to education and new information and communication technologies.

In the municipality of Sintra, as in many other municipalities in the coastal regions of Portugal, urban sprawl has an historical background linked to traditional agricultural activities, complemented later by the rise of other sectors, namely the third and partly the second sector, which now spread across the territory creating new employment opportunities outside the compact city. Among all the municipalities that constitute the Lisbon Metropolitan Area, Sintra is the one that registered the greatest demographic growth between 1991 and 2001, a decade that accounted for a great deal of dispersion throughout the Portuguese territory, accentuating this tendency of dispersion.

The representativeness of Sintra for such dispersion scenario has been one of the key reasons why we selected this territory as case study for our work. Indeed when selecting a case for a case study, researchers use information-oriented sampling. Moreover, a case may be chosen because of the inherent interest of the case or the circumstances surrounding it: in this case the big urban dispersion of Sintra’s municipal territory and the occasion of the revision of its Plano Director Municipal. Alternatively a case study may be chosen because of researchers' in-depth local knowledge, as was the case of Sintra where the bureau of planning of the Municipality provided most of the data required for the work. Whatever the reason for the choice of a case study, there is a distinction to be made between the subject and the object of the case study. The subject is the "practical, historical unity" through which the theoretical focus of the study is being viewed, while the object is that theoretical focus – the analytical frame (Thomas, 2011). For the present work, the subject is Sintra’s territorial development and the revision of its PDM, while the object is the re-urbanization of sustainable extensive territories.

3.3 The space for a supra-municipal coordination and the case of the Metropolitan Area of Lisbon (AML)

The Portuguese law considers the possibility for local authorities to associate for the purpose of jointly carrying out their duties. Such supra-municipal territorial division, corresponding to inter-municipal entities, may be metropolitan areas and intercity communities. Both of them are endowed with deliberative, executive and even consultative powers. However, unlike the representative bodies of local authorities, the bodies of intermunicipal entities are not elected by direct suffrage. In Portugal there are two metropolitan areas (Lisbon Metropolitan Area - AML and Porto Metropolitan Area - AMP) and 21 intercity communities (CIM). "In recent years, inter-municipal entities, namely the metropolitan areas, have been gaining relevance in terms of their attributions and competences in the scope of urban development, namely in terms of planning and management of the territorial economic, social and environmental development strategy." (Direcção-Geral do Território, 2016).

As stated by the law 10/2003 ("Lei 10/2003, 2003-05-13," n.d.), the Metropolitan Area of Lisbon (AML) is a public collective person of associative nature and of territorial scope, that aims to reach common public interests of the municipalities that integrate it. The municipalities included in the AML are eighteen in total: Alcochete, Almada, Barreiro, Cascais, Lisboa, Loures, Mafra, Moita, Montijo, Odivelas, Oeiras, Palmela, Sesimbra, Setúbal, Seixal, Vila Franca de Xira and finally Sintra.

The AML is composed by three organs:

- *Junta Metropolitana*, executive organ, composed by the eighteen presidents of the city halls that are part of the AML. They also elect among themselves, a president and two vice presidents.
- *Assembleia Metropolitana*, legislative organ, composed by the chosen representatives in the municipal assembly of the city halls, in odd number, over the triple the number of the towns that it integrates, in a maximum of fiftyfive.
- *Conselho Metropolitano*, consultative organ, composed by representatives of the Portuguese State and by the members of the *Junta Metropolitana*.

Such administrative structure is in charge of harmonizing territorial policies and strategic planning among the eighteen municipalities in integrates and therefore serves as a major entity for coordinating the development and the decision-making process over the territory of the AML. Among such plans there is also the Plano Regional de Ordenamento do Território da Área Metropolitana de Lisboa (PROT-AML). In such plan, Sintra municipality was assigned to the second metropolitan ring of the AML, along with Cascais, Malveira, Torres Vedras, Benavente-Samora Correia and Setúbal.

Figure 2 - Map of the Metropolitan Area of Lisbon, showing the municipalities that are part of it.

3.4 The relevance of Sintra as a case study

The Metropolitan Area of Lisbon is one the regions in Portugal where the extent and the rate of territorial dispersion are more exacerbated. However, the biggest magnitude of territorial dispersion in the AML is to be found in the municipalities mostly characterized by agricultural activities. Being Sintra one of them. In fact, in the AML the dispersed urbanization occupies about 8.5% of the territory, being more present in those municipalities that still have a clear agricultural character. The structure of the property, and the morphology of the land itself are associated with two very distinct characteristics of the phenomenon. On the north bank of the Tagus, the patches are smaller and more fragmented, while on the south bank they reach large dimensions and continuity. With the increase of mobility, this phenomenon has been accentuated over the last decade, especially in the densification of the dispersion spots. (Carvalho & Abreu, 2011)

Sintra with is 382.521 inhabitants (Instituto Nacional de Estatística, 2012) is one of the five most populated municipalities in Portugal together with Lisboa, Vila Nova de Gaia, Porto and Cascais. Sintra is also the third municipality in terms of number of active companies representing the 3,26% of the whole country. It sits between Lisboa (8,7% of the whole country's total), Porto (3,29%) in front and Vila Nova de Gaia

(2,6%) and Cascais (2,41%) following. Sintra is also one of the municipalities that registered the greatest demographic growth between 1991 and 2001, accentuating this tendency of dispersion, among the whole country with a net increase of 39.4% in a ten years span only. The parishes with urban characteristics that showed strong growth were: Massamá (36.2%), Monte Abraão (33.9%) and Rio de Mouro (32%).

It is clear from these figures that Sintra's territory constitutes an interesting case study to test our hypothesis regarding the analysis and the planning process involved in the regulation of territories characterized by strong territorial dispersion. Moreover, Sintra's Municipality embarked on a process of revision of its PDM in 2012 therefore offering a good example and a good benchmark for comparing the methods and the solutions employed by the PDM of Sintra with our methods and frameworks for territorial analyses and decision-making support.

3.5 Sintra's territory

The municipality of Sintra is part of the Metropolitan Area of Lisbon (AML), that is made up of 18 municipalities for a total land area of 2,934.8 km2. Sintra also integrates the Greater Lisbon sub-region (NUTIII), corresponding to AML Norte, occupying around 23.2% of such territory. The municipality of Sintra is bordered to the north by the municipality of Mafra, to the south by the municipalities of Oeiras and Cascais, to the east by Odivelas, Loures and Amadora, and to the west by the Atlantic Ocean with 25 km of coast.

The municipality of Sintra, occupying an area of 319.2 km2 and having a resident population of 377,835 inhabitants according to the definitive results of Censos 2011, stands out in the national and regional context for its territorial size and population dimension, being the 2nd most populous municipality, just behind the municipality of Lisbon. Within the national and regional context, the municipality of Sintra represents:

- 3.57% of the total national population (10,562,178 inhabitants);
- 13.37% of the total population of the Lisbon Metropolitan Area (2,821,876 inhabitants);
- 19.82% of the total population of Greater Lisbon (1,905,591 inhabitants).

The municipality of Sintra, in addition to its territorial size and population size, is also distinguished by the heterogeneity of its territory.

Located to the west of the Lisbon Metropolitan Area, Sintra's municipal territory presents a very irregular surface where the Serra de Sintra and Serra da Carregueira stand out. Sintra in fact is situated at the extreme end of the orographic line with the northeast-southwest orientation formed by the Sierras de Aire, Candeeiros and Montemouro, culminating in the Sintra massif.

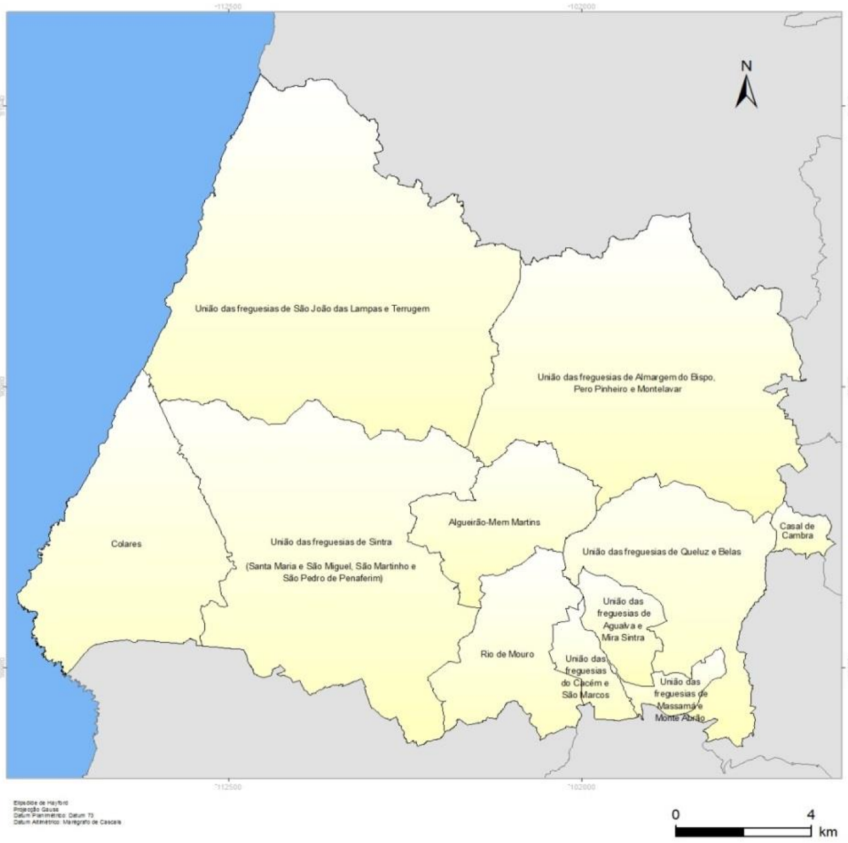

Figure 3 - The freguesias of the municipal territory of Sintra

The Serra de Sintra, with its steep slopes and maximum altitude of 528 meters above sea level, develops in east-west direction, near the Atlantic Coast, extending its south slope to the municipality of Cascais.

The Serra da Carregueira fades into the continuity of the undulating landscape occupying the southwest corner of the municipality, with a maximum altitude of 334 meters.

It is worth mentioning the difference between the two massifs, with the Serra de Sintra rising in an area of low altitudes, surrounded to the north by the Várzea de Colares, to the west by the Atlantic Ocean and to the east by Abrunheira, while the Serra da Carregueira inserts into a panorama of smooth hills. With the two main elevations clearly above 200 meters, the largest area of the municipality is below this level. Almost the entire coastal area of the municipality lies below 100 meters of altitude, with the water lines of Falcão, Samarra, Mata-Magoito and Colares.

The lowlands mark also the border to the northern limit of the municipality with the Rio de Cheleiros, and extend to the south in a narrow strip next to the Ribeira da Cabrela-Fervença. The lowlands of Ribeiras d'Ossos and Estribeira end up to the municipality of Oeiras. Below the 200 meters, with hills and green landscape there is a vast area of good agricultural vocation, which constitutes the greater part of Sintra's territory. This central area is delimited by São das Lampas, Odrinhas, Negrais and Montelavar, and

incorporates the Granja do Marquês and Campo Raso, extending all the way to the south to Linhó, Albarraque, Rio de Mouro, Agualva, Belas and Queluz.

The municipal area of Sintra hosts areas with an important natural value, such as the Sintra-Cascais Natural Park and a heritage landscape with extraordinary cultural, historical and monumental value constituted by the complex of the Vila and Serra de Sintra, recognized by UNESCO as World Heritage Site.

The complex and wide territorial composition that characterizes the municipal territory is served and crossed by a system of mobility and access roads and railway line that guarantee, in addition to the internal connections, the main connections with the neighboring municipalities and to the rest of the AML.

3.6 Sintra's territorial development

Natural and human factors led to the establishment of several urban agglomerations over the centuries throughout what later became the municipal territory of Sintra. The proximity to the water lines in areas where the orography was more favorable, as well as the fertility of the soil, were decisive for the rise of the first settlements, while their influence continues to the present day.

The proximity to major transportation roads, namely the Royal Roads Sintra – Mafra, Lisbon – Mafra and Lisbon – Sintra and, subsequently, the proximity to the railways were also important factors for attracting and fixing the population.

At the beginning of the twentieth century, the settlement with greater importance were:

- Sintra and Queluz (due to the long presence of royalty and court as well as the aristocracy),

- those that were municipalities until 1855 (Colares e Belas),

- and the area of Pero Pinheiro / Montelavar of pre-Roman occupation, with a very relevant extractive industry.

In the twentieth century, the development of the so-called urban axis of Sintra is, in fact, intimately connected with the construction and the development of a railway line which connects the stations of Rossio in Lisbon and Sintra. The railway was one of the first to be planned in Portugal, and was opened on 2 April 1887. Since the beginning of the 20th century, the railway line Lisbon-Sintra induced the emergence of some urban conglomerates developing around railway stations, namely Algueirão-Mem Martins, Rio de Mouro, Mercês and Cacém. At that time, these areas still had their own characteristics of centrality, without depending on the capital city.

Throughout the 1930s and 1940s the traditional housing units still maintained, in general, the simple structure of a one or two floors, grouped in organically arranged clusters. The conglomerates were typically compact and structured by narrow paths and a few open spaces. The rural north and center areas of the municipality can still be

described to some extent in these terms, although more recently the clusters tended to become more dispersed with scattered units.

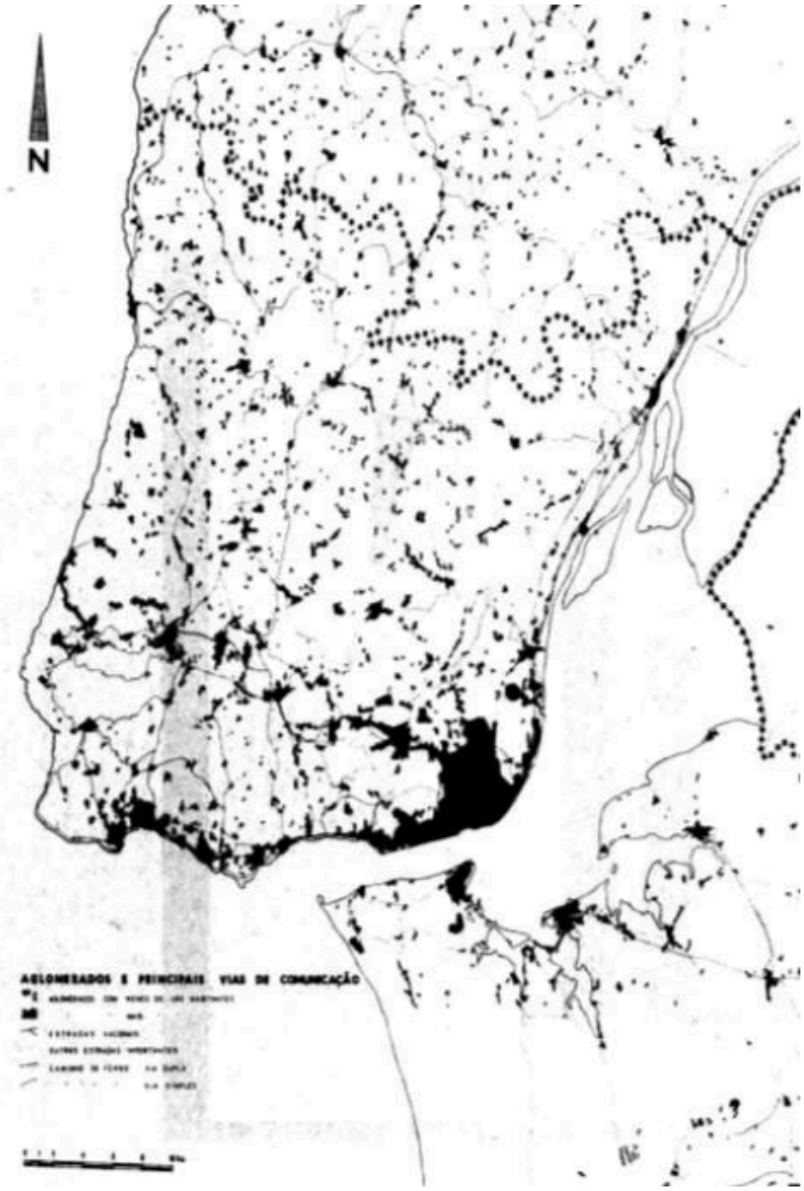

Figure 4 - Master Plan of the Lisbon Region, 1964: Cartogram nº14 - Survey and Analysis - Agglomerates and Transportation Paths

The “dormitory” character of these areas, which to some extents continues nowadays, stems from the development of Lisbon as a tertiary employment hub and the need to establish links with employee markets with good accessibility to the city center. Thus, from the 1960s, the development of the Queluz – Agualva-Cacém – Algueirão-Mem Martins axis began. Motivated by the lack of development of the rural areas of the country, the populations of these regions originated a strong migratory flow to the big cities in search of better living conditions. This translated into the search for affordable housing, something that has had its answer in the uncontrolled, disorderly and illegal

development of the peripheries through clandestine urbanization (AUGI), that extended up to the 1990s.

One of the greatest examples of this phenomenon in Sintra is to be found in Casal de Cambra, whose development (often under circumstances that would hardly find a legal framework) eventually led to the creation of a parish of its own. From then on, the saturation of the urban corridor led to the densification of clusters and the displacement of some urban population to rural or coastal areas (Cacém, Algueirão-Mem Martins, Almoçageme, Nafarros or Praia das Macas).

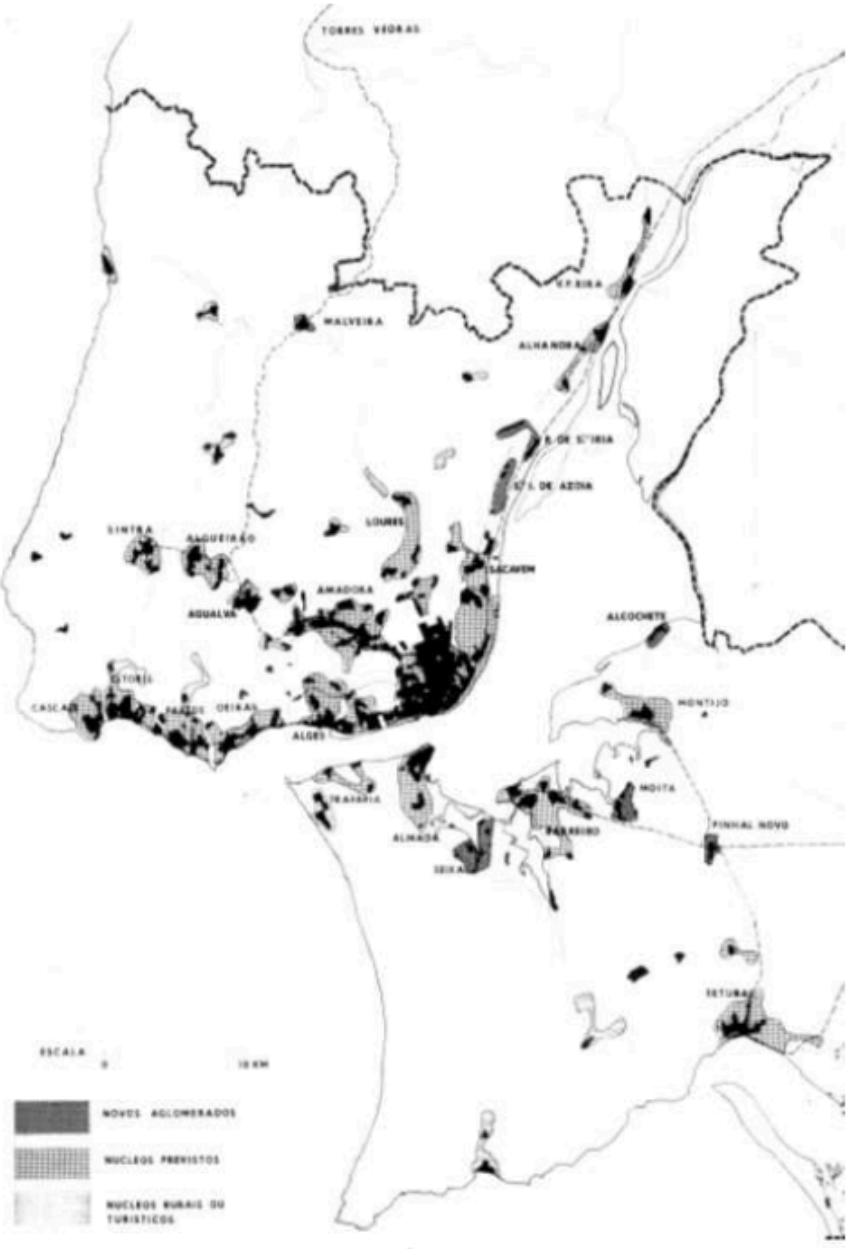

Figure 5 - Master Plan of Lisbon Region, 1964: Regional Urban Structure - consolidated urban centers are represented in black.

The developmental outbreak of the postwar and during the 1960s (which resulted in the emergence of the functional core of the metropolitan area of Lisbon) was characterized by the increase in the rate of private transportation and the growth of motorized public transport, by the development of light industry, by the emergence of tourism activities and an increased demand of the second residences. In this context Lisbon emerged as a pole of tertiary employment leading to the growth of dormitory towns located in places of good accessibility to Lisbon's city center. Such phenomenon radically influenced the socioeconomic life of Sintra's municipality, especially in the urban axis, until recent days.

3.7 Sintra's territorial units

The factors previously described contributed to the transformation of the landscape of Sintra's municipality, resulting in several typologically different structures, denoting the complexity of the territory and constituting "units", grouped on the basis of intervention criteria and of their intrinsic characteristics:

- The northern part of the municipality, polarized around São João das Lampas and Almargem do Bispo, where the mix of traditional and dispersed settlements has been affected by the appearance of industrial units but especially by the construction of new residential units (some for the purposes of second residence of a population mostly from Lisbon), adding up to the traditionally dispersed character of the rural settlements;

- Atlantic Coastal Area and Agricultural Area of the North. Until recent years, these two areas were demographically and economically not very active (showing signs of regressive population dynamics associated with aging population and relatively low levels of education). However, traditional conglomerates of the coastal areas started to be subject to the dynamics of tourism and second residence (Fontanelas, Magoito, Azenhas do Mar, Praia das Maçãs, Colares, Almoçageme, Azóia). The rural areas of the North are located outside the area of influence of the most intense urbanization processes. However, these centres are important catalysts of urbanity and social cohesion for a significant part of the territory of Sintra.
  In the Atlantic Coastal Area of the North the maintenance of agriculture, even as a complement to other activities, and the development of specific regulations for dispersed urbanisation, are fundamental for the preservation of such landscape and the maintenance of attractiveness for quality tourism. In the interior of the agricultural North, agriculture and livestock farming are in a position to maintain themselves, mainly because there is a strong tradition of production of quality products such as wine, vegetables and cheeses that benefit from a strong market. However there are already signs of disordered occupation of the territory that must contrasted and regulated. In this two territories, thanks to the potential derived from the presence of a very rich, natural, historical and archaeological heritage, product of a resistant ethnography, it is gaining ground a qualified

exposure of the territory to a diversity of tourism activities that could gently and opportunely complement the traditional activities of the area;

- The industrial and logistics area at the North of the urban arc. This area configures itself as an industrial and logistics zone, defined territorially by the identification of specialized poles such as Terrugem / Mem Martins / Sabugo / Pêro Pinheiro / Montelavar (which constitute the borders of the urban-rural fringe of the north the AML), but also Abrunheira / Rio de Mouro / Albarraque and Capa Rota, the surroundings of Agualva-Cacém and the industrial zone of Massamá. The industrial zones of Pêro Pinheiro and Montelavar deeply are affected by the extraction and transformation of the stone, that left deep marks in the territory, not only because of the quarries themselves but also because of the worsening of the environmental quality caused by the processing of the stone that typically took place in that area;

- The urban axis Amadora – Sintra where the long urban strip developed in an almost absolute continuum between Lisbon and Algueirão-Mem Martins. Such area presents consolidated urban fabrics - the old urban nuclei that constituted the anchors of the initial phase of suburban expansion emanating from Lisbon - and the more suburban areas which began to emerge in the 1960s and 1970s, constituted by private urbanizations of greater or lower urban quality, and by the consolidation of neighborhoods of illegal nature, self-constructed (what is usually called in Portugal AUGI);
  The development of this urban corridor over the last decades has been remarkable. Much of this growth has been concentrated along the axis of Sintra's railway line and has been comprised between the two main high-speed road connections (the IC19 and A16). Such vast area grew rapidly under a migration input and presents nowadays expressive marks of weak structuring of the urbanization developed in those decedes when Sintra was growing at a very high rate. These areas now feature low indices of quality of construction and of the public space, culminating to situations in which in some areas, there is already a need to renovate the entire built-up fabric as a result of the high level of degradation of some poorly built housing districts, as well as the decline and abandonment of some industrial facilities.
  However, even considering that this area presents major deficiencies in terms of internal road links and functional articulation, it is clearly evident that an urban potential of consolidation and diversification of the economic base exists, provided it is properly oriented and organized.

- Lastly Sintra's Mountain and historical town. The Sintra Mountain, containing the Cultural Landscape classified by UNESCO as World Heritage, constitutes a unique landscape in the AML, presenting a high geological, geomorphological, floristic and faunistic value. This unit also includes the Vila de Sintra Velha, which, together with the mountains, presents an historical-cultural heritage of

great value and great tourist attractiveness that resisted the banalization of the landscape due to its peculiar geographical context, as well as by the enforcing of planning regulation, and by the very conscience that its inhabitants have of the value of their urban landscape.

From this territorial classification it is easy to understand how Sintra's territory is characterized by different territorial units that present different types of territorial dispersion. Each of them has to be treated independently in order to be correctly analysed and possibly contrasted when needed.

3.8 Sintra's different types of settlement

Since the beginning of the century, as we have seen, the railway line has induced some more urban deployments near the stations, namely Algueirão-Mem Martins, Rio de Mouro and Cacém. The presence of the palace of Queluz, on the other hand, had its influence on the surrounding area since the eighteenth century.

Throughout the 1930s and 1940s, the traditional housing unit, directly emanating from a rural way of life, still generally maintained the simple one- or two-story building structure, mostly grouped into organically arranged agglomerates. The orography and the characteristics of the places influenced this development: compact, with narrow alleys and small open spaces.

The post-war development boom of the 1960s (which resulted in the constitution of the functional core of the metropolitan area) had characteristics that had a strong impact on the territory: the increased motorization rate and the growth of motorized public transport, the development of light industry, the growing appetite for tourist activities and second residences, the constitution of Lisbon as a tertiary employment hub and the corollary establishment of dormitory towns in places with good accessibility to the capital city center. All these socioeconomic phenomena decisively influenced the structure of the settlement in the municipality of Sintra, especially in the urban axis Sintra-Lisbon.

The factors previously described contributed to the landscape transformation, resulting in the constitution of several typologically diverse units:

- The coastal zone: the traditional settlements are today subjected to the dynamics of tourism and second residences demand (Fontanelas, Magoito, Azenhas do Mar, Praia das Macas, Colares, Almoçageme, Azóia);
- The inland zone: the northern strip of the municipality, polarized by São João das Lampas and Almargem do Bispo, with the mix of old and scattered settlements, both in individual units and larger farms, has long been disturbed by the appearance of some factories and tourist units, but above all by the construction of new units (some for the purpose of second residence of an outside population, mainly of Lisbon), increasing the scattered character of the settlements and spreading the occupation until then mainly agricultural;

- The “industrial” zone (Pêro Pinheiro / Montelavar): the extraction and transformation of the stone gave rise to profound marks in the territory, not only due to the effect of the quarries themselves but also due to the poor environmental quality caused by the processing units. Associated to this, there is also a urban development induced by the presence of stone factories and stone commercialization;
- The urban area: the long urban strip that stretches on an almost absolute continuum between Lisbon and Algueirão - Mem Martins presents consolidated urban spaces - the old urban centers that were the anchors of the initial phase of Lisbon-centered suburban expansion - the suburban areas themselves, which began to emerge in the 60's and in the 70's, that are further integrated by private urbanizations - with higher or lower urban quality - and some illegal self-built neighborhoods. The town of Sintra, with the presence of the most relevant historical heritage, for the most part classified, has resisted the de-characterization, either because of the peculiar geographical situation, either because of the enforcement of the urbanistic norms, or because of the conscience that its inhabitants have of the value of their heritage landscape.

Figure 6 - Territorial Development Model proposed by the latest revision of the PDM of Sintra

In the next paragraphs we will attempt to typify the structures that can be found in the municipality by presenting particular examples illustrating general cases.

3.8.1 Compact settlements of the coastal zone

These are clusters whose genesis predates the phenomenon of the second residence. The nuclei are, therefore, relatively compact, of single family typology, usually growing from an anchor point (church, square, intersection - or all of these) and hence developing into small units of blocks. In one place or another, blocks of the same shape are visible: these are newer buildings, which have responded to the demand for second homes (or simply new homes), but with characteristics that are totally different from those of the historical cores to which they are adjacent.

The case of Praia das Maçãs is completely different though: it is a cluster that has long taken advantage of its vocation as a seaside resort (see allotment permits from the 1980s); typology varies between single-family houses (from detached units to townhouses) and multi-family, with a reticular block structure, symptomatic of a planned construction on a larger scale than Fontanelas and Almoçageme. Nevertheless the most original compact core (along the beach) and the linear structure along the main road are still clearly distinguishable.

3.8.2 Compact settlements of the interior

The characteristics are similar to those of coastal agglomerations (single family typology, usually growing from an anchor point and then developing into a small meshwork of blocks). However, the nuclei are less compact, dispersing linearly along the main axes marking the centrifugal expansion of the cluster.

The typology is still mostly single-family, however they are usually not of second residences but hoses of the new residents of such area who found work in the local industry or tertiary sector.

3.8.3 Industrial zones

Although the original nuclei (dense, single-family types, identifiable around the church and later the Parish Council building, schools, and other equipments and services) are identifiable, the volumes with the greatest visibility are undoubtedly those of the large pavilions, occupying large parcels adjacent to the historical nuclei or implanted within the most central areas of the original nuclei along the National Roads: EN9 (Sintra-Mafra) and EN117 (Queluz-Mafra). Even the construction of a new road (a section of the Via de Cintura of the Metropolitan Area of Lisbon) was not enough to solve the problem: the industry is still completely embedded in the urban core.

3.8.4 Urban areas

The formation of the urban corridor has already been widely addressed in the previous pages. At this point, we only intend to demonstrate the impact of this evolution on the structure of the settlements along the axis Lisbon-Sintra, the most densely populated area of the municipality. The example of Agualva-Cacém - the largest cluster in the municipality and one of the largest cities in the Metropolitan Area of Lisbon - is iconic. Here it it is possible to find multiple typologies (single and single-family, multi-family

in compact blocks or isolated towers, industrial compounds, etc.) and the most varied types of territory organization (along pre-existing roads, in new blocks, around squares, along the river, etc.). In Agualva-Cacém there is diversity in the layout of buildings, there are equipments, services; and especially after the Polis project that started in 2001 ("Decreto-Lei 43/2001, 2001-02-09," n.d.) the public space presents "events" (squares, gardens, etc.) that give value and qualify the space, giving it an identity that is absent, for example, in Massamá or Rio de Mouro. One explanation for this (besides the Polis project) is the evolution of the city's construction process, which was nonetheless slow compared to other urban corridor settlements. Take as example the neighboring settlement of Massamá (especially in the case of Casal da Barota) where 80% of the territory was structured between 1980 and 2000 and supported by a small number of bulding permits that gave rise to dozens of buildings and hundreds identical residential units. Here the only structuring element is the road system, with the ground floors reserved for trade and services, which rely only on the sidewalk (rarely in a square or square that serves more than parking), and with no elements that effectively break the monotony of the road.

Another example is Rio de Mouro - Rinchoa, with characteristics similar to those of Massamá, but having a zone of single-family typology to the north (next to the railway station), relatively isolated from the large multifamily buildings thanks to its orography, which allowed the creation of a very different space. The rest of the territory has the same problem: dozens of buildings and hundreds of residential units rose from few building permits, largely decrepit now. One explanation lies in the land structure itself: while in the 1953 *Cadastro Rústico* of Cacém was already quite segmented, not lending itself to large allotment operations, the same was not true of Rio de Mouro and Massamá, still segmented in large parcels. The example of Cacém extends to Algueirão - Mem Martins or even Queluz (with the differences that are recognized to the latter in terms of qualification of public space, and the presence of the Palace has long given the city an identity that is very strong. The Palace is a strong anchor of territorial structure that makes it the most special settlement of all the rest of the urban corridor.

3.8.5 The town of Sintra

Sintra deserves its own treatment: municipality capital, endpoint of the extensive urban corridor, a UNESCO world heritage site. In terms of urban structure, it consists of four nuclei: Vila Velha, São Pedro de Penaferrim, Estefânia and Portela. Out of these, only Portela could in fact have been subjected to the same processes as the other settlements of the urban axis. However, whether due to the land structure or the distance to Lisbon, Portela did not lose its character as happened with other settlements of the urban axis.

São Pedro de Penaferrim, was founded possibly due to the construction of the early Church of São Pedro in the thirteenth century, and has since been a parish. At present days, it is predominantly a housing area, with some trade supply (mostly niche trade such as antiques and decoration). Estefânia is an urban settlement founded in 1855 by D. Pedro V, named after his wife. It was developed around the railroad, and in 1874, with the construction of the Lisbon - Sintra line, the first houses were built. Already at

the end of the nineteenth century open new streets, born from old roads, giving rise to bourgeois housing estates. Currently, Estefânia has characteristics of a civic center, where administrative activities of the village are concentrated (some relocated in Portela), as well as cultural facilities of supra-municipal scope, such as the Olga Cadaval Cultural Center. And finally Vila Velha, the central nucleus that corresponds to the densest and oldest settlement of Sintra. This space, of medieval settlement, is structured by the public square bordering the Vila Palace, where also arises the main road structure of Vila Velha. Set in terrain with quite different dimensions, this area is characterized by the structuring presence of quadrangular interior courtyards around which the buildings are developed. The urban network is thus compact and irregular, marked by streets that show true mazes and that propagate without apparent rule, representing mere spaces of communication. The houses, with tight and low arches, invade the sidewalks and narrow them. The village matrix, in turn, reflects the defensive character of the past. In this central nucleus, the building consists predominantly of current housing units, which coexist with farmhouses, palatial houses, religious buildings and public buildings, in an architecture that, at certain times, intersects with the lush green landscape. Sintra was the first Cultural Landscape in Europe, classified in 1995.

3.8.6 Areas of dispersed urbanization

The classification of the “areas of dispersed urbanization” in rural areas is framed in the Regulatory Decree No. 15/2015, which states that the areas to be classified as of dispersed urbanization are the ones corresponding to existing built-up areas with “hybrid characteristics and an urban-rural occupation. These areas should be the subject of a land use regime that ensures their containment and planning in a sustainability perspective, using solutions appropriate to their own characteristics”. (“Decreto Regulamentar 15/2015, 2015-08-19,” n.d.)

Moreover, the Plano Regional de Ordenamento do Território do Oeste e Vale do Tejo, fulfilling one of the guidelines ("Structuring of dispersed built-up areas"), divides the dispersed built-up areas into two categories, which are thought to closely represent the reality of the territory of Sintra:

- Extensive dispersed built-up areas.
- Linear dispersed built-up areas

3.8.6.1 Extensive dispersed built-up areas

The extensive dispersed built-up areas are areas without a defined structure, scattered over a mostly rural or mixed territory in which the population develops in spots, sometimes in large extensions. They usually result from a singularity in the territory (an old country house or farm, for example) around which new buildings gathered and spread out without great organization (this structure is also frequently in the so-called AUGI – or areas of illegal genesis).

3.8.6.2 Linear dispersed built-up areas

The settlement with a linear structure derives from the perception of the proximity to a path as an opportunity to gain an ideal location for trade (due to the visibility achieved by the building) or even for housing or industry (motivated by the easy accessibility).

The conglomeration through cross-direction expansion typical of the development of historic villages and centers never occurs in this kind of urbanization. The conglomeration stays attached to the road, following invariably a linear development and preventing the rise of effective neighborhood relations or the emergence of true central functions.

3.8.7 Industrial activities dispersion

In order to conclude the characterization of the elements that contributed to the dispersion the built-up area in Sintra, it is necessary to mention the industrial fabric and the business parks. The municipality of Sintra constitutes a vast territory, that has undergone since the decade of 1960s a big housing densification process and unprecedented population growth, making it one of the most populous towns at the level of the Metropolitan Area of Lisbon - and even at national level.

In addition to this process, economic activities were implemented, mainly tertiary, that replaced the other sectors. However, in the rural lands (of the coastal area and inland) strong dispersion dynamics took place leaving visible signs in the way the territory is organized. The result is a territorial dispersion that is linked to agricultural activity but augmented by the dispersion dynamics generated by the decentralization of the productive activities that relocated in large volumes of industrial pavilions dispersed through the once rural only territory. The densification process on the other hand stabilized along the urban corridor of the IC19 road from Lisbon to Sintra, and has being bordered to the north by the A16, which constituted an opportunity to contain the expansion urbanization.

Now the opportunity to re-densify and consolidate what was built in a poorly planned way in the past, and is constituted by the rehabilitation and regeneration of the spaces built in 1960-70 (that being half a century old, already are in need for intervention and rehabilitation). The potential of the town of Sintra as a tourist attraction, as well as that of the coastal zone, may attract new activities and empower existing ones, attracting residents (not necessarily in these areas, but perhaps in those older urban centers scattered through the rural territory that are now emptying but that can be the epicenters of a new territorial re-densification and regeneration. In this context the renovation of old industrial zones (such as the one of Montelavar - Pêro Pinheiro - Maceira triangle) can be pivotal to the requalification of this dispersed territory.

3.9 The review processes of PDMs of CCDR LVT

The municipal master plans (PDM) are framed by the Law of general basis of public policy of land, land use and urban planning - *Lei de bases gerais da política pública de solos, de ordenamento do território e de urbanismo* ("Lei n.º 31/2014, de 30 de Maio,"

n.d.) - and the Decree-Law No. 80/20 of the Legal Regime of Territorial Management Instruments. These municipal territorial plans are mandatory - unless there is an inter-municipal master plan - and establish the municipal territorial development strategy, the municipal territorial mode and the options for location and management of collective equipment and interdependence relations with neighboring municipalities. The preparation and review of municipal master plans (PDMs) are accompanied by committees, comprising representatives of entities and services of direct or indirect state administration.

The preparation and review of the PDMs is responsibility of the municipal councils and the work should be ensured by a consultative committee of a collegial character, coordinated and chaired by the territorially competent Commission of Coordination and Regional Development (CCDR), and regulated by *Portaria* n.º 277/2015. The constitution, composition, powers and functioning of these committees or commissions have been regulated since 1982, following the evolution of the various legal regimes on the preparation of the PDM.

Here is a list of the legislation that have been stipulated over the last 30 years the procedures for preparation and the monitoring of these municipal plans.

Table 1 - List of legislative reforms regulating the PDM preparation

Law	Monitoring body
Decree-Law No. 208/82, of 26 May - Article 12	Monitoring Committee - CA
Decree-Law No. 69/90, of March 2 - Article 6	Technical Commission - CTA
Decree-Law No. 155/97, of June 24 (which amended DL No. 69/90)	Technical Commission - CTA
Decree-Law No. 380/99, of 22 September - Article 75	Joint Coordination Commission - CMC
Ordinance No. 290/2003, of April 5th (published following RJIGT)	Joint Coordination Commission - CMC
Decree-Law No. 316/2007, of 19 September (5th amendment to RJIGT) - article 75 A	Monitoring Committee - CA
Ordinance No. 1474/2007 of 16 November + Statement of Rectification No. 1-C / 2008	Monitoring Committee - CA

of 15 January 2008 (published following DL 316/2007)	
Decree-Law no.80 / 2015, of 14 May (RJIGT revision) - article 83	Consultative Committee - CC
Ordinance No. 277/2015, of September 10th (published following DL 80/2015)	Consultative Committee - CC

The Portaria n.º 277/2015 is the legislative act currently in force, which regulates the constitution, composition and operation of advisory committees for the preparation and review of municipal and inter-municipal master plans. This law has significantly changed the follow-up procedure of the plan preparation, in particular as it is now supported by a collaborative platform and allows for a significant reduction in the number of plenary meetings, favoring sectoral meetings.

For the case of Sintra, the task of coordinating the preparing and revision of the PDM is assigned to the Commission of Coordination and Regional Development of Lisboa and Vale do Tejo (CCDR LVT). CCDR LVT's area of operation, within the scope of spatial planning, covers 52 municipalities within 5 NUTS III areas. Aiming to contribute to the knowledge of the state of spatial planning in this region, particularly on the development of management tools, the CCDR LVT prepares quarterly a Report on the LVT region's PDMs reviews.

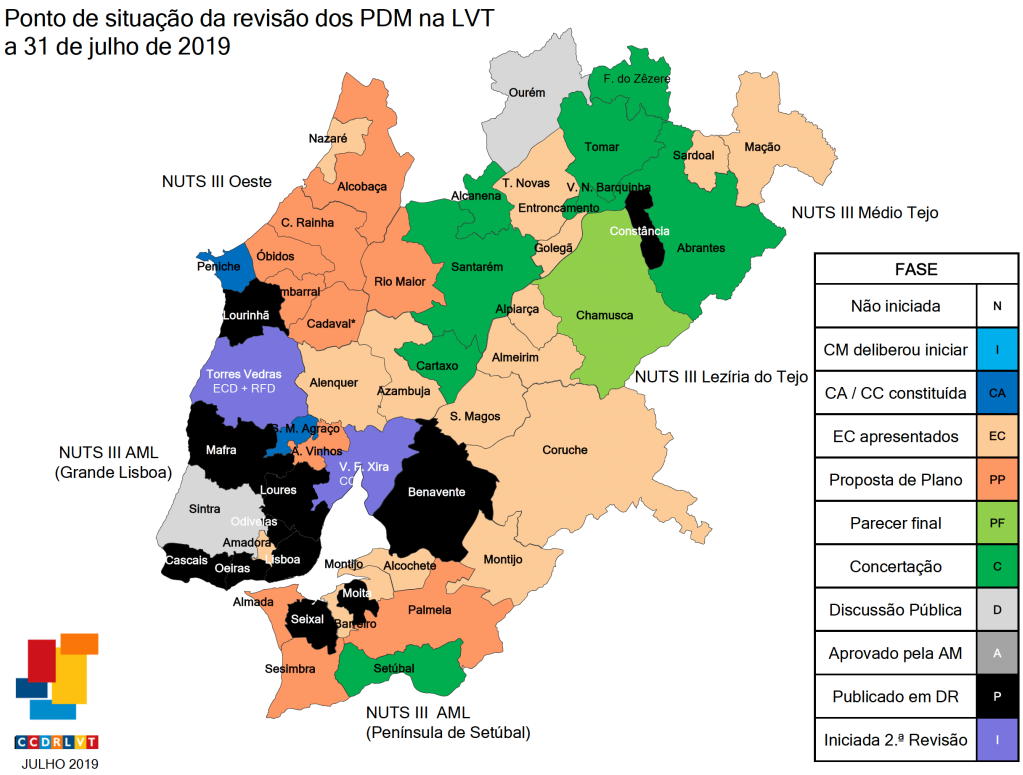

Figure 7 - Status of PDMs revisions in the LVT region in July 2019

3.10 A brief history of Sintra's PDM

The first Municipal Master Plan (PDM) of Sintra was approved in 1999 by the Resolution of the Council of Ministers nº. 116/99 ("Resolução do Conselho de Ministros 116/99, 1999-10-04," n.d.). This plan constituted the first instrument of land use planning policy in Sintra, having resisted for over a decade and half in force.

This Plan was prepared under the regime established by Decree-Law No. 69/90 ("Decreto-Lei 69/90, 1990-03-02," n.d.), a legislative act that regulated municipal plans for spatial planning, being therefore prior to the legal regime of territorial management instruments ("Decreto-Lei 380/99, 1999-09-22," n.d.) that created a new territorial management system.

Such Decree-Law outlined in a quite different period from the current one, when the municipality of Sintra was the fastest growing municipality in the Lisbon Metropolitan Area, with housing and business demand profiles quite different from those of today, gave birth to a PDM that was quickly overtaken by reality. Future prospects at national level now point to a demographic contraction and a significant population aging, which is less severe in Sintra than in other municipalities of the AML, but still featuring worrying figures, with all the consequences that such a change may have on economy and quality of life. The 2011 national census by the Instituto Nacional de Estatística (2012) revealed a strong mismatch between the demographic estimate of the municipality and reality.

The review of Sintra PDM became therefore an important topic for the Municipality at the point that on July 25th 2012 the City Council deliberates the start of such revision with the Proposal nº 476P/2012 ("Câmara Municipal de Sintra—Cloud," n.d.).

A period of preventive public participation followed from December 28th 2012 to March 25th 2013. In 2013, a CCDR LVT preparatory meeting is held to define the entities that would constitute the Monitoring Committee of the planning process: its constitution is defined in the Aviso 2840/2013 ("Aviso 2840/2013, 2013-02-27," n.d.). In 2014, the Plan Coordinator was appointed, pursuant to the City Council Deliberation of 2012, and to Order No. 47-P / 2014. The revision of the Sintra PDM advances then, developed by the municipal services - Municipal Directorate of Environment, Planning and Territory Management / Municipal Master Plan Office, with the collaboration of the Instituto Superior Técnico fo the Strategic Environmental Assessment, pursuant to Decree Law No. 232/2007, in its updated version ("Decreto-Lei 232/2007, 2007-06-15," n.d.). On April 22nd 2014, the City Council determined the work plan and strategic methodology for the revision of the PDM of Sintra, with the proposal 254-P/2014, considering this instrument and its revision, strategic for the economic and sustainable development of the municipality. The finalization of the drafting, appraisal and approval process was achieved by the end of the first quarter of 2017.

However, in 2014, the new General Law on Public Land Policy, Spatial Planning and Urbanism Law was published ("Lei n.º 31/2014, de 30 de Maio," n.d.), introducing significant changes to the land management system and soil policy. One of the main changes is the disappearance of the operative category of the so-called "urbanizable land" – or solo urbanizável – clearly stating that urban land is the one that is fully or partially urbanized and built, and that the soil programmed to be urbanized will have to follow a longer path to be approved. In the meantime, the studies leading to the diagnosis of the PDM have been developed and completed in early 2015 and submitted to the Monitoring Committee on January 29th 2015.

During this period several forms of participation with the citizens and stakeholders, organizations and associations of the municipality, took place in articulation with the works of the Environmental Strategic Evaluation, namely the conduction of a survey to the citizens (December 2014), a Focusing Workshop of the Environmental Strategic Evaluation (November 2014) and another Workshop for the discussion of "Strategic Options" for the territory of Sintra (May 2015).

At the same time, studies were carried out for the elaboration of the National Ecological Reserve (REN), that is the identification of the various ecological systems and their occurrence, according to the Decree Law nº. 166/2008 ("Regime Jurídico da Reserva Ecológica Nacional," n.d.), as well as studies for the delimitation of the National Agricultural Reserve (RAN) areas in conjunction with the Regional Directorate for Agriculture and Fisheries of Lisbon and Tagus Valley (DRAPLVT).

The REN delimitation proposal was sent for the opinion of the public interest representatives in 2015 and the final works have already been weighted with the opinions issued. The first version of the RAN proposal (1st stage of the process) was prepared by the DRAPLVT and Sintra's City Council developed the final proposal based on these studies. With the completion of the diagnosis phase of the work for the revision of the PDM of Sintra, it was possible to advance one step forward in order to get to the definition of a territorial strategy that would guide the entire revision of the PDM. Such strategy culminated in the Territorial Development Model (MDT) of Sintra, which reflects the strategy to be developed in the PDM revision, thus being the main guiding document for the works that would follow. The presentation of the diagnosis, the Territorial Development Model (MDT) and also the Report on the Critical Factors of the Strategic Environmental Assessment (SEA) took place in a public session, open to any interested party or citizen, on March 5, 2015.

3.11 Sintra's PDM future strategies

In order to be able to get a richer descriptions of the context in which this work is inserted, the revision of the PDM of Sintra that started in 2012, and to be able to make relevant theoretical connections between the municipality's work and the approach chosen by the present work, we decided to conduct an interview to one of the key experts employed in the process of revision of the PDM of Sintra, Tiago Trigueiros, head of the bureau of the PDM at the Municipality of Sintra.

The interviewee first explained that the goal for this PDM revision has been trying to imagine what the future of Sintra could look like, supporting the political decision-making process with layers of information and insights coming from a series of studies, reflections and analyses supported by geographic information systems. The bureau of the PDM has been in charge of developing a territorial strategy for the municipality of Sintra that led to a Territorial Development Model. Such model has been discussed and approved in the municipal assembly in 2015, as we have previously seen, in order – as Tiago Trigueiros puts it – "to set the course" for the rest of the PDM revision. With the strategy approved, in fact, the planners of the bureau for PDM could develop the plan without incurring in the risk of having the initial strategy refused after the completion of the whole PDM revision. Such sequence of actions (having the Territorial Development Model approved first, and the rest of the PDM revision done later) consisted in a big practice innovation within the Portuguese context, that could well be exported to other PDM revisions in other municipalities. Sintra's PDM revision has been much more ambitious than the previous municipal plans and largely more corrective towards the critical points generated by lack of planning or undesired territorial dynamics that this last revision tries to corrected.

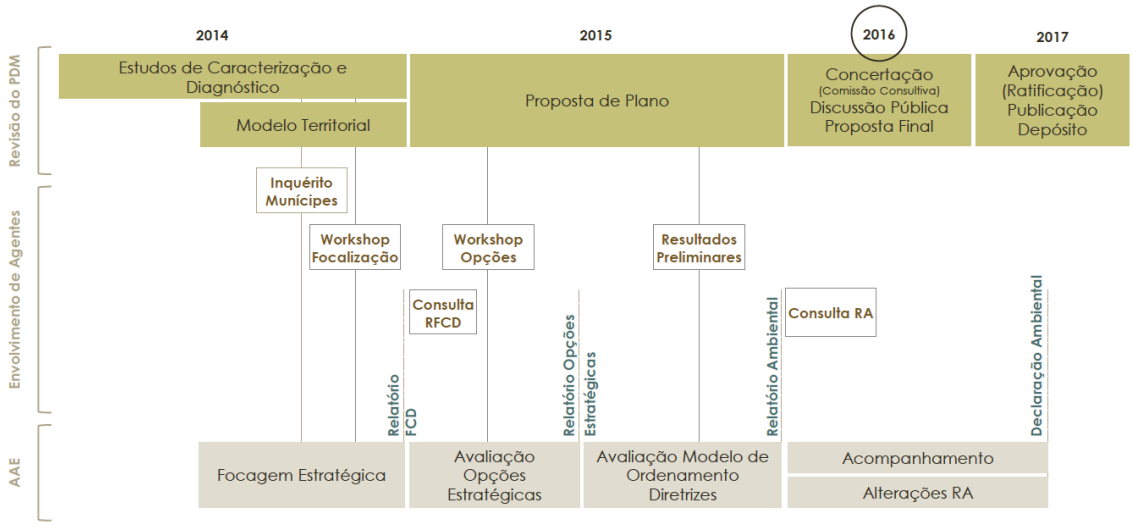

Figure 8 - Methodologic strategy approved by the municipality of Sintra for the revision of the PDM in 2014

The aim, as Tiago Trigueiros explains, is to achieve a territory that is more sustainable and optimized in which all the aspects contribute to the fostering of life quality, for all the people living, working or visiting Sintra - with urban regeneration projects, public spaces intervention, regenerating infrastructures, services, green spaces, walkable districts.

Sintra has undergone a big development with lots of real estate projects and urbanizations so that now the challenge now is to redesign and regenerate those parts of the territory that had scarce urban quality in the first place. The goal is to go from an urban axis along railway, to a polycentric, multidisciplinary city with three big urban green parks.

A special focus is reserved to business parks to be regenerated and connected with the residential areas in a mobility scheme that allows for great walkability and better life quality. Hopefully this would allow for the rise of new economies connected with the business parks that would also push for private investment for the regeneration of those parks. Sintra's territorial strategy for the different identities that constitute the territory of Sintra. Nevertheless, the treatment that each of these different territorial units within the PDM revision is the same. No difference has been made between the criteria and the level of conservation, for example, on the cultural heritage of Sintra's UNESCO classified town center and an heritage building from a more peripheral - and less known - part of the territory.

Tiago Trigueiros also commented the legislative context in which the current PDM revision is taking place. He said that the latest reforms introduced by the *Lei de bases gerais da política pública de solos, de ordenamento do território e de urbanismo* made things easier on one hand and more difficult on another for the Municipality of Sintra. In fact, as he explained, from the first wave of PDMs only 20% more or less of the urbanizable land has been urbanised. This means that Portuguese municipalities planned a lot of excess in construction that jeopardized the sustainability of the territory. This

because the territory has been urbanized in a piecemeal way making necessary the construction and the maintenance of a big infrastructure system that is costly and inefficient. Such infrastructures are maintained by the IMI tax finances. Parallel to that there has been also a lack of agricultural land because the territory has been occupied and urbanized in an unorganized - and again in a piecemeal - way.

There is a conscience in many municipalities that a corrective intervention is needed – the interviewee said. In this respect, the new Lei de Bases came to give more ground and justification, in his opinion, to such corrective measures, namely the reduction of the urban areas. It is easier to explain to somebody that an area is passing from being urbanizable to being considered rural land when it is stated by a national law.

The downside of this, in Tiago Trigueiros' view, is that the law restricts the discretional opinion of the municipality on how and when to design such boundaries between urban and rural. This also because that are cases where the municipality could have had the interest of designing such boundaries in a different way also allowing for some sort of possible future development. With the suppression of the urbanizable land category, any land available for possible future development ceases to exist[11].

Tiago Trigueiros then goes on by questioning, how would it be if a big investor would arrive to Sintra with the intention of installing on the territory a big facility? How would the municipality be able to provide a large area for urbanisation when all the territory is just categorized in urbanised and rural?

This issue has been also presented by Nuno Ventura at a seminar organized by CCDR LTV in 2017 ("Seminário | Urbanismo para o Futuro das Cidades," n.d.) talking about how to solve the issue of how to solve the conflict between not having an urbanizable land category and the potential need for available land for new investments. To solve this issue Nuno Ventura proposes a hybrid solution with areas that could be made ready for investment and development in a very short lapse of time, as parts of territory that - due to the importance of the project on a metropolitan level - can be considered potentially urbanizable areas.

[11] This is a personal opinion expressed by the interviewee, on which it is possible to agree or not.

The importance of giving answer to the rapid changes in the territory and to the bottom-up dynamics that emerge from the civil society is crucial for every planning effort.

PDMs are usually slow to develop and implement that's why it is important to foresee hybrid tools that make possible the quick response of the municipality in case a large investment could be made on the territory so that the invest wouldn't run away desisting from the investment.

Other operations like urban acupuncture or localised projects of urban renovation can make a big difference and cast a big effect even outside of a total revision of a PDM, e.g. the reformulation of the traffic scheme for Sintra's historic center. This intervention, as Tiago Trigueiros explains, took out the cars from the UNESCO site, thus generating a big return value for the whole system of Villa de Sintra both making more amenable to areas of historic center and boosting the tourism economy that started to enjoy new car-free public spaces.

In fact, the central aim of this work has been – from the very beginning – to develop an operative framework and a set of methods capable of contributing to:

- the development of effective strategic planning tools driven by an in-depth territorial analysis supported by the most up to date data available;
- the development of a decision-support tool that could help administrations and decision-makers to make strategic decisions based on up to date geolocated territorial data;
- the setup of a permanent feedback system that, by being fed by updated territorial data, will make possible the quick assessment of the ever-changing territorial dynamics and enable the administration to give a quick response to matters related to territorial governance.

By proving this set of tools and methods to the realm of urban planning and governance for the territory of Sintra, the present work aims at contributing to the sustainable and smart development of the territory of Sintra, testing a methodology that – if successful in Sintra – could be later implied in other contexts.

The interview with Tiago Trigueiros ended with an invitation to show the outcome that will be generated by the present work, to discuss it together and also to check if there could be any synergy between the methods used in the PDM revision and the framework proposed by the present work.

PART 2 - METHODOLOGY

4. RESEARCH DESIGN AND METHODOLOGY

This chapter provides an overview of the whole research design, giving the rationale behind each individual choice and introducing the reader to the datasets used in the work, and to the main quantitative methods applied to analyze and explore such data.

We will start our digression into the design process of the present research by presenting the principal concepts and methodological steps that guided the unfolding of the whole research from its preliminary assumptions to the implementation of the model and the evaluation of its results.

In the present research we have chosen to follow two important design decisions made right at the beginning of this work:

- First, to maintain an observational stance, given the fact that the study – as it is conceived now – doesn't impact the development of territorial strategies on the field.
- Secondly, to employ quantitative methods only. Instead of looking at the territory from the perspective of traditional urban morphology studies, we tried to incorporate notions derived from different fields into the quantitative analyses we performed for the selected territory.

In order to address the research aims and key questions presented in the introductory chapter, the present work performs an empirical study to test the real-world possibility of proposing a conceptual and operational framework capable of guiding through the decision-making process of developing municipal and regional masterplans in a perspective of re-urbanization of extensive territories.

4.1 Research aim and objectives

The present work is based on the concept of territorial capital (Camagni, 2007; Camagni & Capello, 2013; Camagni, Capello, & Nijkamp, 2009) and it is focused on the definition of a framework of indicators that can translate the concept of territorial capital into practice, keeping in mind the availability of relevant data and the strategic priorities of Sintra's municipal planning. Ultimately, the goal of this study is to propose an additional methodology to traditional planning methods.

The same methodology allows, from a perspective of analysis and validation, to scrutinize development scenarios proposed at the territorial level. To achieve this goal, it was necessary to define an articulated set of indicators that allowed to test the territorial development scenarios proposed by the recent update of the Plano Director Municipal of Sintra, taking into account essentially aspects related to territorial distribution, such as:

a) the occupation density (built and population);

b) accessibility and connectivity (network analysis);

c) uses and activities.

This approach enabled us to incorporate in a single model a very wide array of data about the territory, taking into account various territorial data to create an operative custom framework to calculate the territorial capital of each individual location within Sintra's municipality. After an extensive scrutiny of the literature as well as a process of empirical nature, we succeed at creating our own set of territorial capital indicators grouping them in four main dimensions, which reflected the different lines of research of the present work. The selected dimensions are therefore:

Demographics, intended as the distribution of population, its segmentation in different groups, as well as the occurrence of different features and their distribution in the territory;
Occupation, intended as land occupation and distribution of buildings and built-up areas over the territory;

- Functions, intended as the distribution, variety and type of different economic functions within Sintra's territory;
- Networks and accessibility, intended as the study of the accessibility patterns of the present building as well as built-up areas.

The concept of territorial capital is expressed in this work by the analytic study of the articulation of these four dimensions together. In fact, the methodologic challenge of this work has been from the very beginning that of bringing together information and data coming from very different realms into one single operative model.

4.1.1 Uses of the proposed model

The same operative model that we propose here in fact allows to scrutinize, from a perspective of analysis and validation, the territorial development scenarios proposed at the municipal level as well as to test a new stance to municipal planning guided by data-driven approach to territorial profiling. In this respect, the proposed methodology allows for the assessment of the differentials in performance of Sintra's different locations, focusing on the potential for re-urbanization for any given location inside Sintra's municipal territory. In order to do so, the development scenarios put forward by the most recent update of the Plano Director Municipal of Sintra have been analysed and assessed under the light of the territorial capital perspective that we incorporated in our framework.

Such conceptual framework by taking into account the territorial context of the region, its territorial capital and its local constraints, aims at supporting the decision-making process at the strategic level. That is, what may lead to choose one scenario of territorial development over another.

In fact, the proposed method aims to allow to spatialize potential development scenarios and thus help to:

1) support strategic decision making;

2) translate strategic options into specific territorial policies, for municipalities or for wider administrational units, i.e. inter-municipal and metropolitan entities.

Such framework is intended to provide to the decision makers a better understanding of the territory analysed by giving a series of insights into a wide variety of realms and synthetizing them in a holistic view. Such all-comprising holistic view will serve to take more informed decisions for the future development of the urban system ensuring a better achievement of policy goals related territorial, economic and social sustainability. This level of understanding of the territory can ultimately lead executives to choose for one developmente scenario over another or one intervention area over another.

The present study therefore describes the morphological, spatial and socio-economic characteristics of the region in order to identify potentials for sustainable development under different development scenarios within Sintra's territory. In order to test such theoretical and methodological framework a case study has been selected: the municipal area of Sintra, Portugal.

4.2 The research approach explained

The present research relies heavily on a set of quantitative methods employed throughout the work to analyze, characterize and classify the study area from a measurable and replicable point of view. Such approach has been at the very basis of the work since its conception.

The selection of the individual methods has been informed by the latest achievements in the regional studies as well as in the geographic information software (GIS) techniques. The guiding principle of such selection is the inherent holistic approach that pervades the whole analytic work: the idea that in order to analyze and model the different variables that shape the social dynamics, the territorial development and the economic performance of a place, an all-comprising, holistic approach is needed. Historically, the planning practice failed to integrate in a single framework all the diverse contribution from different fields as census information, density studies, network analysis, economic activities surveys, etc. (Clifton, Ewing, Knaap, & Song, 2008; Paddison, 1964). In truth, the implementation of such holistic set of methods proves to be challenging endeavor from a conceptual as well as instrumental point of view. But the current availability of

methods and techniques to gather and cross-analyze different kinds of data, makes the work viable and relatively linear now more than ever.

In other to be able to aggregate such a diverse array of analyses and data coming from different realms and fields of study, we decided to take a strict quantitative approach to the elaboration of such data. Though a system of normalizations and numeric calculus, the results of each analyses were standardized in order to be amenable to comparisons and cross-reference. A system of ratings ensured that each dataset was introduced with its correct weight in the overall system. The rationale behind this choice has been the conviction that only a truly holistic look at the whole urban system with all its territorial, economic and social dynamics involved will have rendered a precise information for the support of strategic decisions that could ensure sustainability and feasibility in the long run. The aforementioned approach implies however a heavy employment of different kinds of data and the relative treatment, analysis and interpretation. In fact, data treatment and data analysis are central topics in this kind of work. We will discuss all these topics more in details in the paragraphs dedicated to the methods employed in the different steps of the work.

For now, it is important to acknowledge that such set of quantitative methods, rating systems and holistic approaches to the territorial analysis proved to be key for looking at the territory from an overall perspective and producing a more realistic understanding of the complex social, economic and territorial dynamics constantly shaping and reshaping the territory and its development. Moreover, such approach proved to be robust and straight-forward enough to be replicated in other contexts and for other case studies, always keeping in mind the scalability of the project. Moving forward from the general research aim of the work – implementing a conceptual and operational framework capable of guiding through the decision-making process of a masterplan while maintaining a perspective of re-urbanization of extensive territories – we shall look at how the proposed methodology helps reaching this goal and how it applies in practice.

4.3 Research workflow

The present thesis represents an effort towards the implementation of an original framework of territorial analysis that – under the light of the territorial capital theory – could be used to assess pontentials and vocations for different parts of the territory, especially in a perspective of re-urbanization of dispersed urbanized areas.
In order to do that, a specific workflow encompassing all the needed steps to achieve such goals has to be designed from scratch.

To summarize the workflow we can point at the main steps here, illustrated in Figure 9:

- Review of the relevant literature over the concepts of urban dispersion, re-urbanization and territorial capital
- Selection of the case study: Sintra, Portugal
- Data gathering, database and reporting grid preparation
- The aggregation of territorial data onto the custom reporting grid

- Selection of the territorial indicators to be used
- Territorial analyses
- Aggregation of the results onto the custom reporting grid
- Spatialization of the SWOT analysis and territorial profiling
- Discussion of the results
- Conclusions

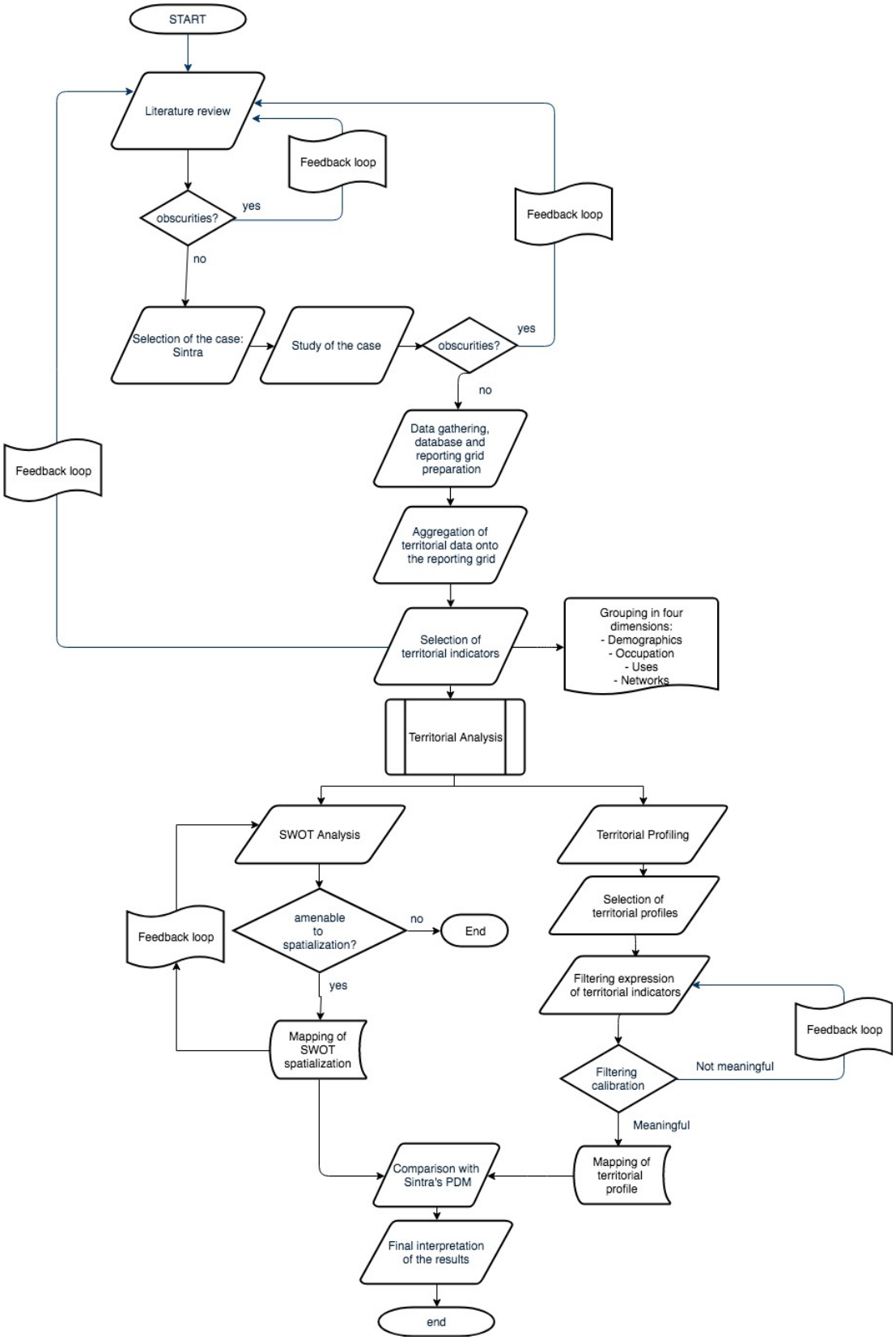

Figure 9 - Diagram of the research's workflow

4.4 Literature review

The literature review has been defined by a guiding concept of the present work, the idea that to tackle the issues posed by the contemporary territory a multidisciplinary

approach to territorial analysis, strategic planning and territorial modelling is needed. The theme of the re-urbanization of extensive dispersed territories which is the specific issue that we are discussing here, also has been given relevance in the review.

The review of the relevant literature for this work has been focused on three main research areas:

- Studies on territorial dispersion
- Theories answering to the territorial dispersion
- Studies on territorial capital as a tool to foster regional competitiveness

By critically analyzing the information gathered about these three areas of study we identify as a major gap in current practice the fact the most of the planning processes at municipal and regional level fail to take into account the different socio-economic dynamics that shape the territory and the ever-changing nature of such dynamics, thus they struggle to keep up with change and emerging territorial trends. For this reason we decided to embrace a multidisciplinary, data-driven approach to this study, in order to be able to cope with the quick socio-economic changes of the contemporary territories.

The literature review served initially to investigate the areas of study invested by the present work, getting acquainted with the latest development of each field. But beside summarizing prior research and saying how our work is linked to it, the review of the literature also served as a repository of ideas and solutions whenever we had some doubt or obscurity about a certain step in the thesis workflow. Particularly, research decisions like what case study to select, what territorial indicators to choose have benefited from the feedback of a second iteration of the literature review. Such feedback loop allowed to review decisions, adjust them to the newly found results and align them with the current debate over that specific argument.

4.5 The selection of the case study

After the review of the literature, we concentrated on the selection of the case study. In a way, such selection has been the direct result of the literature review. The fact of choosing a Portuguese case study, and Sintra in particular, are the results of literature considerations that pointed out at widespread issues related to urban dispersion over the Portuguese territory. The three main urban conglomerates of the country: the Metropolitan Area of Oporto, the Metropolitan Area of Lisbon and the urban conglomeration of Algarve are the regions in Portugal where the extent and the rate of territorial dispersion are more exacerbated.

However, we chose Sintra for being more accessible in terms of data (the municipality agreed on providing us with some of their territorial data) and for being one of the municipalities in the AML with the biggest magnitude of territorial dispersion. In fact, as we found out, the areas with biggest magnitude of territorial dispersion are the ones mostly characterized by agricultural activities. Ultimately, the framework tested in this thesis was conceived having in mind the goal of developing a workflow capable of being replicated on other case studies both in Portugal and elsewhere. So it is fair to say

that we selected Sintra for this study but that we could have selected another case that would have been equally valid for the sake of this work, reflecting at how multidisciplinary, data-driven approaches to planning can help tackle the issue of territorial dispersion by helping design and guide the process of public and private investment over the territory in a context of re-urbanization and foresting of territorial capital.

4.6 Selection and collection of information

The next step has been selecting and collecting the relevant information (and data) about the case study. A valuable source of information proved to be the documents created by the municipality of Sintra in the context of the latest revision of its PDM. Such documentation included preliminary studies, technical reports, development models and ultimately a proposal of a new masterplan.

All this information has been at the basis at our work for either containing pieces of information that help us form hypotheses on the development scenarios for Sintra's territory, or for constituting a reference point to weight the results of our territorial analyses. Ultimately, the mappings resulting from the territorial analysis performed by the municipality of Sintra served as a reference for our mappings and analyses, while the items of the SWOT analysis presented in the PDM revision were given a new expression by spatializing them and aggregating them to the grid proposed in this work. Such grid with its finer resolution helped highlighting territorial dynamics and trends that were simply impossible to spot at the statistical subsection level proposed by INE.

4.7 The choice of the territorial indicators

The concept of sustainability needs to be given operational forms if it is to influence and count in the strategic planning (Gallent & Wong, 2009; Wong & Watkins, 2009) – even more in plans for re-urbanization of extensive dispersed territories, as it is in this work. Such a prerogative has been acknowledged by many policy makers entities and scholars over the last two decades, and the term indicators is often evoked as an important element in this respect. In the present research we chose to make use of indicators to measure and to study key features of the territorial capital of territory under analysis. The assumption here is that indicators are knowledge tools at the core of territorial capital analyses.

An indicator (from the Latin word "indicare" meaning to point out, to announce, to give notice of) is used to measure or evaluate a particular characteristic of interest. In the broader sense indicators in scientific research seek to represent a phenomenon of interest. Therefore, indicators are often selected to best represent one or more attributes (qualities, characteristics, properties) of the system under study. In fact, an often-cited definition of indicators is that of Gallopín: "desirable indicators are those that summarize or otherwise simplify relevant information, makes visible or perceptible phenomena of interest, and quantify, measure, and communicate relevant information" (Gallopín, 1996, p. 108). On the other hand, Gudmundsson et al. define indicators as "a

variable, or a combination of variables, selected to represent a certain wider issue or characteristic of interest" (Gudmundsson, Hall, Marsden, & Zietsman, 2015, p. 139).

One could ask however why are indicators needed? In general, indicators are important, as they provide focused information on the key issues involved. Moving forward from planning to decision-making, to implementation, to monitoring and evaluation of actions is almost impossible without indicators. The first key feature of an indicator is that it can be measured or observed by following a defined procedure. To be credible, indicators should be able to represent the phenomenon they intend to measure and be consistent in this representation. That means they should meet criteria for scientific soundness – or representativity what Gudmundsson et al. call it (2015). Indicators to be representative of a certain phenomenon they intend to measure should be clear (well defined), valid (based on confirmed causal mechanisms), reliable (predictable and reproducible via a measurement process), sensitive (accurately capture changes), and robust (insensitive to interferences). Closely related to this are concerns of measurability: this is mainly a practical concern about data availability of data (a big issue regarding the Portuguese context) or cost-effectiveness in obtaining data. We shall reserve a paragraphs of this thesis to the topic of the availability of data and the importance of open-data for research development. As many studies proved, in fact, there is a strong correlation between the availability of open data and innovation at national and regional level (Jetzek, Avital, & Bjorn-Andersen, 2014). We will discuss this topic in full detail further in the thesis. Moreover, it is important to note that indicators are constructed: the targets they intend to support, the selection of the appropriate indicator(s), the elaboration of the method, their level of aggregation, and their presentation are all subjective choices made by researchers in order to build his own interpretative model of the analyzed phenomenon.

Lastly, indicators should also be useful. In fact, some recent literature on the matter talks of 'usability' to refer to the potential use, influence and impact of the selected indicators (Bauler, 2012). Moreover, the 'acceptability' of an indicator is also an important feature to consider before choosing it for a specific research. In other words it is also important selecting indicators that resonate well with the context of the potential stakeholders in the area. Also related to this, it is the role of selected indicators in supporting processes of transition such as creating shared understanding between groups of stakeholders and enabling coalition formation between different experts from different research areas. In this respect, indicators carry a huge potential to *challenge* the status quo in socio-technical transitions, by opening up policy discourses and questioning prevailing practices, frameworks of thought and hegemonic discourses (Lehtonen, Sébastien, & Bauler, 2016).

As a conclusion to the issues raised so far, we provides a simple summary in the following figure of the main steps involved in indicator design and selection, seen as an iterative (i.e. repeated and with no clear starting point) process.

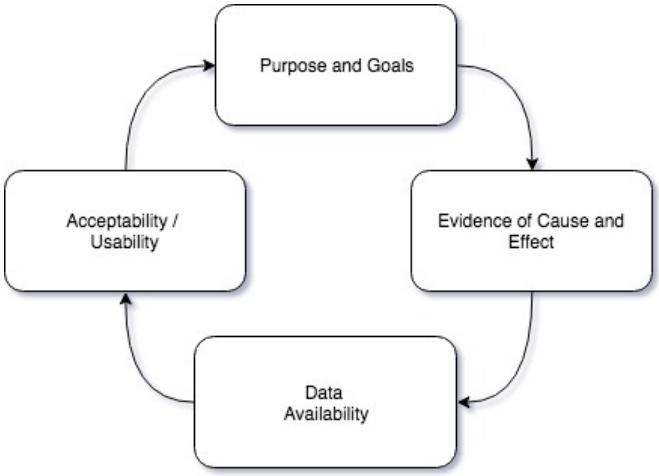

Figure 10: Four essential features of an iterative process of indicator development.

4.8 An overview on the selected indicators

To get back to the indicators selection, we must note that the choice of the relevant indicators for the present work has been based on the concept of territorial capital.

The type of indicators to use, many aspects to employ, and the level of detail of the indicators are very important, something that is often dependent on the context of their use. Different decision-making processes rely on different quantities and types of indicators.

What we aimed for with our choice here has been to be able to look at the territory, its potentials and its dynamics, with an holistic point of view that would allow us to take informed decisions over the strategic planning for the territory of Sintra. In this respect the indicators in the present research constitute the backbone structure that made possible the implementation of a decision-making support system capable of guiding through the processes involved with strategic planning in the municipal/regional context.

It is important to note also that such decision-making support systems, based on the territorial indicators to be presented here, served both as reporting and assessment tools for the strategic territorial planning of Sintra. As we have seen in the previous chapters the concept of territorial capital entails the inclusion of different dimensions to determine the overall performance and dynamics of a territory. Following such conceptualization, a territory's economic and social development is influenced by a series of variables that can be grouped into different dimensions. In the present work we developed a framework of indicators grouped in four dimensions: demographics, occupation, functions, network.

Here we will give an account of the indicators selected for each dimension. Table 2 illustrates what indicators go under each dimension. In the next paragraphs we will

describe each dimension getting into each indicator one by one, explaining the rationale behind its choice.

Dimensions	Selected indicators
Demographics	Population having completed at least secondary education
	Population over 65 years old
	New dwellings 1991-2011
	Unemployed looking for a job
Occupation	Population density
	Gross Space Index
	Dispersion Index
	Empty Dwellings
Functions	Diversity Simpson Index
	Number of activities of 1st sector
	Number of activities of 2nd sector
	Number of activities of 3rd sector
Network	Choice 5km
	Integration 5km
	Infrastructure density
	Number of culs-de-sac

Table 2 - Selected Territorial Capital Indicators

4.8.1 Demographics dimension

The first dimension we analysed in this work has been the demographic dimension. For this dimension we selected four indicators that represent different aspects of the population characteristics and population dynamics. This set of indicators did not include any "space" consideration but rather they only describe demographics. This is the main different between this dimension and the Occupation dimension: for this reason, the indicator New Dwellings 1991-2011 is included in this dimension while population density is included in the Occupation dimension. The indicators included here give us a good perspective on the populational processes at play over Sintra's territory.

The demographic dimension is composed of the following indicators:

- Population having completed at least secondary education
- Population over 65 years old
- New dwellings 1991-2011
- Unemployed looking for a job

While these four indicators express different sides of the demographic dimension, they all contribute to illustrate population trends. In fact, levels of education, of unemployment, of aging population and rates of residential units growth collaborate to provide a better understanding of the dynamics of a population within a given territory.

The indicator “New dwelligs 1991-2011” is part of this dimension. In fact, we considered this indicator here as a good indicator of the increase of new residents in a certain area: as the population increases and rejuvenates, the housing capacity also increases.

The indicator “Resident population having completed at least secondary education” represents the number of residents with upper secondary or tertiary education attainment, which translates to the International Standard Classification of Education (ISCED) in education levels between levels 5-8. As the UNESCO education strategy 2014-2021 underlines, education is a basic human right and the foundation for more sustainable, inclusive and just development (“UNESCO education strategy 2014-2021—UNESCO Digital Library,” n.d.). As the Estratégia Nacional de Desenvolvimento Sustentável (2004) points out, the qualification of human resources is crucial for the Portuguese economy and society to ensure sustained growth in the near future.

The indicator “Resident population aged 65 and over” is representative of the aging of the population. As the Estratégia Nacional de Desenvolvimento Sustentável (2004) points out: “the aging of the population dramatically alters the balance between the working population and the dependent population, requiring innovative responses to support the latter, as well as retarding the aggravated dynamics of dependence (including physical and mental), poverty and exclusion.” In the present work we will see that, depending on the scenario that is analyzed, such indicator can either have a negative sign or a positive sign.

The indicator “New dwellings 1991-2011” represents the number of new housing units constructed between 1991 and 2011. As we said, this indicator is able signal areas of urban expansion as well as areas of population increase. It is important also to compare it with the population data. In our research this indicator can either be highlight areas where urban dispersion is currently taking place or areas where urban consolidation and demographic concentration are taking place.

The indicator of the number of residents “unemployed looking for jobs” is an important indicator that highlights areas of unemployment and possibly low-income enclaves. The

minimization of such values is an important factor to foster and sustain development of a territory.

All these four indicators together give us valuable insight into the "human capital" of Sintra. All the data analysed in this dimension are secondary data originally collected by the Instituto Nacional de Estatística during the Census 2011.

4.8.2 Occupation dimension

For the occupation dimension we selected four indicators that represent different aspects of land occupation, distribution of buildings and built-up areas over the territory.

The occupation dimension is composed of the following indicators:

- Population per hectar
- Gross Space Index (GSI)
- Dispersion Index
- Empty dwellings

This set of indicators gives us a good perspective on the building dynamics and densities (both populational and urban density) at play over Sintra's territory. The occupation dimension gives us a valuable insight in the "agglomeration advantage" of each individual location within Sintra's territory.

The interaction of population density, represented by the indicator "population density" and human capital has a positive and statistically significant effect on urban productivity. In fact, population concentration is a driver of territorial, economic and innovation development.

The GSI, or coverage, demonstrates, on the other hand, the relationship between built and non-built space. This indicator is part of the Resource Efficiency Scoreboard (Commission, 2015). It is used to monitor progress towards a resource efficient Europe.

During the recent decades the share of built-up area in the total area increased remarkably. However, as population density and economic activities are different across Europe, no general rate is defined as a target rate. Moreover, the aim is to reuse areas previously used for instance for industrial purposes (brownfield development), instead of establishing built-up areas on agricultural or woodland areas (greenfield developments) and to ensure that the trend of the increasing share of built-up area comes to a halt. Land is a finite resource and land taken by urban development and infrastructure presents a high risk of being irreversible. The "dispersion index" represents the degree of urban dispersion of the territory. This indicator is able signal areas of urban expansion as well as area of urban stagnation. It has been developed using a custom method capable to measuring the continuity and compacity of what we defined as the buildings' clusters. The original idea stems from a work by Jorge

Carvalho (2013) but here we aimed to refine and further implement the buffer method proposed by him to study the Portuguese territorial dispersion.

The "empty dwellings" indicator on the other hand is capable to render an image of the areas in the territory where there is more demand of dwellings, and the ones where there is less demand. It is important also to compare it with the population data.

4.8.3 Functions dimension

The functions dimension consists of data concerning economic activities, intended as the distribution, variety and type of different economic functions within Sintra's territory.

The functions dimension is composed of the following indicators:

- Dicersity Simpson Index
- Number of economic activities of the 1st sector
- Number of economic activities of the 2nd sector
- Number of economic activities of the 3rd sector

This dimension takes into account the concentration and number of economic activities but also the diversity of those economic activities and functions. This is a crucial point: in recent decades in fact, the mixing of complementary land uses has become an increasingly important goal in planning. Land uses mix has been shown to be a positive influential factor in travel behavior (mode choice and distance traveled), improved health outcomes, and neighborhood-level quality of life (Manaugh & Kreider, 2013).

To measure the degree of land mixed use (or diversity of the land uses as we called it here) and activities, we chose to use an index that comes from outside the fields of urban planning: the Simpson's Diversity Index. The Simpson's Index is, in fact, a common measure of diversity. The index was invented by Edward H. Simpson (1949) to measure the degree of concentration when individuals are classified into types. The measure equals the probability that two entities taken at random from the dataset of interest represent the same type.

In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present in the ecosystem, as well as the abundance of each species, analyzing therefore its richness and sustainability. Here it will see it to quantity the diversity of economic activities ecosystem in Sintra.

The indicators related to the number of economic activities of each sector, on the other hand, measure the concentration of certain economic activities (as part of a specific sector) in any given location of Sintra's territory. Such indices represent the influence and the overall "weight" that each economic sector has on each location of the municipal territory. Since data about economic activities in the municipal archives that we had access to was pretty scarce, we proceeded by creating our own dataset. All these indicators are therefore based on data gathered through a process of web-scraping and

geocoding that allowed us to get the most up to date insights over Sintra's economic activities.

4.8.4 Networks dimension

The network dimension refers to the study of the connectivity of the road network of Sintra. The network analysis proposed in this work take inspiration from a set of methods that stem from the theory of Space Syntax and studies on livable and walkable neighborhoods .
The network dimension is composed of the following indicators:

- Choice 5km
- Integration 5km
- Infrastructure density
- Number of culs-de-sac

Road network characteristics are, in fact, crucial for determining the territorial capital of a region, as they constitute the backbone of the relational capital of that very region, i.e. the capacity of facilitate mobility of people and good and ultimately the exchange of ideas (Capello, Caragliu, & Nijkamp, 2009; Schiuma & Lerro, 2008). Space Syntax is the theory that reflected the most on these topics related to connectivity, walkability and accessibility of place over the last decades. So, in a study about the territorial capital of a place, like ours, the network analysis part and the theory of Space Syntax could not be overlooked. The term space syntax encompasses a set of theories and techniques for the analysis of spatial configurations, both at urban and architectural scale. Originally conceived by Bill Hillier, Julienne Hanson and colleagues (1984) at the University College London in the late 1970s - early 1980s as a tool to help urban planners simulate the likely social effects of their designs, Space Syntax has evolved during the last decade to incorporate novel notions of network analysis. In recent years, efforts were made to integrate space syntax in ordinary GIS research made it possible to utilize the more common features such road centerlines (Thomson, 2004; Turner, 2007) instead of the classic axial lines proposed by Hillier that required much expert interpretation.

The first indicator of this dimension, Choice, measures how likely a street segment it is to be passed through on all shortest routes from all spaces to all other spaces in the entire urban system or within a predetermined distance, radius, (Hillier & Iida, 2005) as in this case. We therefore selected a radius of 5km from each segment in our analysis. This because we considered it a good value to measure the accessibility by car at local level.

We then moved onto the second indicator of road accessibility, Integration. This is a measure of angular distance from any a space of origin to all others in a system – or as in our case within a radius of 5000 meters. It can be seen as the measure of relative topological depth (Hillier & Hanson, 1984). Again the choice of the radius has been dictated by the intention of measuring local accessibility by car.

The indicator of Infrastructure Density looks at Sintra's road network efficiency in providing infrastructure. It is calculated as total length of infrastructure for each single location of Sintra's territory. This indicator also links to connectivity and block size, thus to notions of walkability and neighborhood activity (Dill, 2004).

The last indicator of the Network dimension is the Number of Culs-de-sac. It is an indicator of low local connectivity. Usually the Number of Culs-de-sac is an indicator used in walkability studies (Forsyth, 2015; Lo, 2009) to characterize dense urban neighborhoods as opposed to sprawl-type development.

4.9 The SWOT spatialization

The proposed update of the Plano Director Municipal of Sintra that recently came to completion features a diagnostic report composed of eleven themes or topics. Most of these themes are included in a synthesis that gave place to a SWOT analysis. The SWOT analysis is a strategic planning technique usually used to help an organization to identify strengths, weaknesses, opportunities, and threats related to a project at stake. It is widely used to identify the internal and external factors that are at play in achieving the objectives of the project. SWOT analysis has been applied to spatial planning to emphasize the intrinsic qualities of a space, its vocations and to mitigate or control existing drawbacks or threats.

The SWOT analysis is a tool, mainly of a strategic nature, to support decision making, which owes its name (Stregths, Weaknesses, Opportunities and Threats) to the fact that it deals with the identification of forces, internal weaknesses in a given environment (a company or, in the present case, the area of intervention of a Master Plan), as well as the opportunities and threats of the analyzed area. This synthetic framework provided by each of these dimensions allows the evaluation of the internal and external variables for the development of Sintra's territory, being a fundamental part for the definition of the development strategy for Sintra's territory, that is, of the future visions and of the strategic axes and objectives that materialize it and implement it on the ground. In fact, the SWOT analysis can be used by municipal and regional authorities as a framework for reflection on various development scenarios.

In Chapter 6 we will illustrate step-by-step how we "spatialized" the SWOT analysis proposed by the PDM of Sintra, i.e. how we translated the original SWOT analysis into a more detailed decision-making support tool with a spatial dimension. This was made possible by the construction of the already described set of indicators that led to the mapping of the items of the SWOT analysis onto the territorial grid proposed in this work. Such methodological framework allowed us to reach more conclusive interpretations of the original SWOT analysis as well as of the whole development scenario evaluation for Sintra's territory.

In order to spatialize the items which constitutes the SWOT analysis performed for the revision of the PDM of Sintra municipality, we used our set of indicators – as described in the previous paragraphs – to map actual locations and distribution patterns of strengths, weaknesses, opportunities and threats. To do so, we selected a subset of the whole SWOT analysis items: we considered here the ones that had indeed a spatial expression and also for which we had sufficient data available.

4.10 Territorial profiling

The present research aims at being able to characterize and to profile different parts of the territory from a territorial capital perspective. The idea that has been at the basis of this work since its very beginning is to be able to calculate the aptness of each part of Sintra's territory for a given territorial development scenario. Such intention led naturally to the idea of working with profiles.

Each profile resulted from a specific sequence of values for a specific set of indicators calculated on the custom territorial grid 100x100m chosen as a reporting grid for this work. In order to select different profiles for the given territory, we looked at the Modelo de Desenvolvimento Territorial (MDT) of the PDM of Sintra.

Sintra's MDT, in fact, sought to synthesize policies and strategic visions by territorial units of the territory of Sintra that share similarities together and tries to establish the necessary connections for the system (city / territory) to function in the most efficient way possible. In this respect, the MDT identify areas with specific vocations and potentialities in order to create a territorial system that working as an ensemble could be more competitive and diversified.

The intention we had for this task has been to associate rather generic strategic axes put forward by the Municipality of Sintra in the latest update of their PDM to specific territorial development scenarios. In order to spatialize and quantitively measure the viability of such development scenarios we then decided to associate each scenario to a specific profile, i.e. a specific combination of scores for each indicator. We considered for this work one main development scenario present in the Territorial Development Model that constitutes the central strategic document of the latest PDM revision of Sintra. This scenario has as a goal to transform Sintra's territory into a polycentric territory. Such contained a number of profiles or sub-scenarios that we quantitively assessed and discussed. In order to visualize such profiles on Qgis, we decided to perform a filtering based on multiple criteria (representing the different indicators and the score they have to match in order to meet the criteria).

4.10.1 The profiling calculation

After having considered the hypothesis of grouping the territorial indicators by their dimension, we opted to visualize the territorial profiles in a more detailed way retaining all the information from the different indicators visible to the end user of the tool. To do this, we created a specific set of territorial indicators for each of the scenarios we

inferred from the Territorial Development Model, that constitutes the central strategic document of the latest PDM revision of Sintra. Such set of indicators formed the backbone of the specific profiles we set on identifying. Each profile in fact corresponds to a specific combination of specific scores for each indicator. In this work we concentrated on one main development scenario proposed by the PDM of Sintra: the development scenario of Sintra as polycentric territory.

Here's a mapping illustrating the locations identified as a *Centro Urbano Vivo* matching all the conditions for the specific profile. It possible to see that all the grid cells that didn't match all the conditions posed by the filtering expression have been hidden from this visualization, while the ones highlighted are the locations whose features met the all the criteria of the filtering expression above.

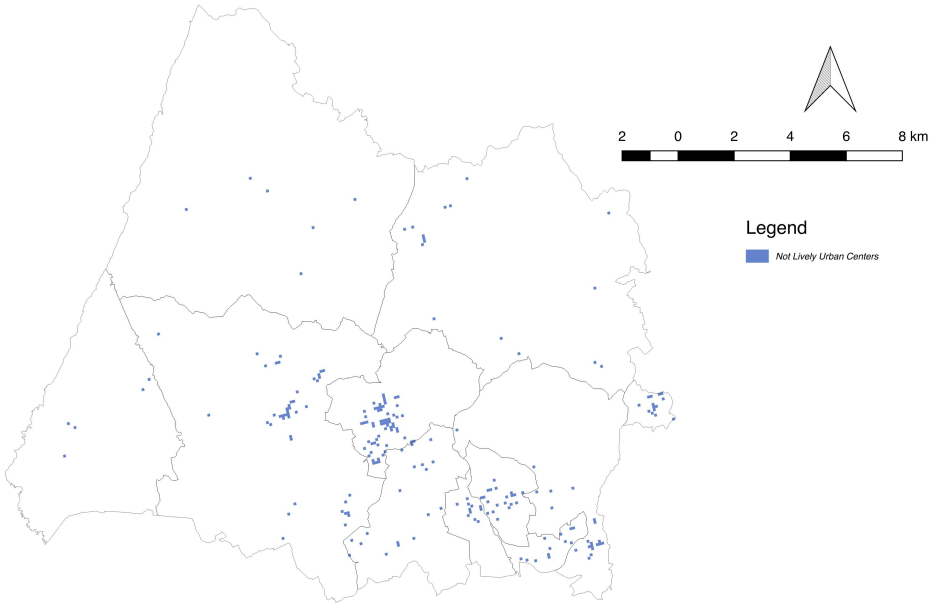

Figure 11 – Example of mapping of territorial profile: Lively Urban Center

This kind of mappings enable a quick and striking visualization of what locations in the territory meet a certain set of criteria, making it possible to stakeholders and decision maker to "play" with the variables in order to find the desired combination of filtering criteria and their threshold values for each territorial profile analyzed.

5. METHODS OF TERRITORIAL ANALYSIS

The approach to decision-making support in territorial planning proposed by the present work implies a heavy employment of different kinds of data, their treatment, analysis and interpretation. In fact, data treatment and data analysis are central topics in such kind of work. In this chapter we will illustrate step-by-step the kind of progression that led from the original datasets to the more complex elaborations and more sophisticated methods of data treatment and geo-processing that allowed more conclusive interpretations of the original data as well as of the whole case study area.

5.1 The role of data in the territorial analyses performed

The territorial analyses performed in this research looked at a fairly wide list of secondary data sources to provide a baseline assessment of existing territorial conditions. Topics includes population, housing, economy, land use, natural environment, resources and sustainability, circulation, community services, parks and recreation centers. Most of the data sets used in this work are spatially defined, which allowed us to store, analyze, and display through a series of maps via a GIS (geographic information system) a wide variety of analyses outputs. These data sets are used to make a series of maps that document a host of land use characteristics that include land use (commercial, industrial, residential, public land); census data; infrastructure; transportation routes; etc. Through the use of such data it has been possible to enquire the system about emerging patterns of territorial dynamics or demographic and economic trends.

Given the broad scope of topics covered, secondary data sources have been chosen to expedite the data gathering process. Whenever possible, the data has been analyzed longitudinally to determine if any significant trends were developing among individual data sets and comparatively to see if any cumulative relationships were developing between data sets. Conclusions drawn from these baseline assessments helped to identify problems and opportunities that provided empirical direction in the assessment of territorial development scenarios.

As we said the present research relies heavily on a set of quantitative methods employed throughout the work to analyze the study area in a measurable and replicable manner. Quantitative research studies, in fact, produce results that can be used to describe or note numerical changes in measurable characteristics of a population of interest; provide explanations of predictions; and explain causal relationships.

5.1.1 Data gathering

Accessing multiple data sets and organizing the research around a mixed-method

investigative strategy is generally standard practice in planning research. This is due to the multifaceted nature of the problems addressed that requires the researcher to access different quantitative data sets in order to generate a holistic understanding about the problem at hand.

The present research relies on an operative framework that entails the use of refined methods of territorial analysis. In fact, for the scope of this research the resolution of the analysis plays a crucial role.

The available data, however, in most cases proved to have a resolution that didn't quite fit to the scope of the present research. This happened for all the data produced by the Instituto Nacional de Estatística, mostly due to the privacy regulation that restrict the publication of personal data to a resolution that can guarantee that the information gathered cannot be linked directly to individuals or family nucleuses.

For this reason, the datasets publicly available have a wider resolution that doesn't allow for a detailed analysis of the territory as the one required in this study.

In fact, the Census data published by INE is aggregated by a cascade of level coming down from the National level, regional level (NUTS II and NUTS III), municipal level, arriving to the level of the Freguesias (the lowest administrational entity in Portugal) and then narrowing down the scope to the INE Statistical Sections and Subsections. The latest being the most disaggregated data made publicly available by INE.

Such resolution of data, however, is still insufficient for the goals set by this research: to analyze in detail and characterize thoroughly the territory of Sintra.

The data used in the current research come from different sources:

- the Census data provided by INE
- the proprietary data provided by the CM Sintra
- road center lines downloaded from Open Street Map
- land coverage data downloaded from the Copernicus European project
- data about locations of business obtain through a process of web-scraping

In the present work data played a crucial role, for them being at basis of the quantitative analyses performed along the whole research.

Without reliable and consistent data such work would not be possible. In order to gather, clean and standardize such data, a work on data preparation has been needed.

First of all, we selected the datasets to work with.

For the sake's of the present research we decided to use mostly secondary data provided by public institutions like INE (National Institute of Statistics, Portugal) and the Municipality of Sintra. The primary information employed in the present research comes from the latest Population and Housing Censuses performed by Instituto Nacional de Estátistica in 2011. These two censuses are the largest and most exhaustive statistical operations the country undertakes. Its main purpose is to provide a complete picture of the country. Such dataset characterizes the people living in the country, the kind of housing they live in and their living conditions.The dataset that we used in this research has been the one related to the municipality of Sintra only. For the sake of this research it has been pivotal to achieve the highest resolution possible for all the data employed. For the data coming from the Census 2011 such level of resolution has been represented by the statistical subsections of the INE.

5.1.2 The choice of secondary data

For the present research we decided to rely on secondary data. The choice has been driven by the need to analyze a big quantity of data that would have been almost impossible to gather without employing secondary data methods.

In fact, there are several advantages to relying on secondary data.

- Time savings. This is even more evident as researchers are relying more heavily on digital data than printed materials housed in libraries. In the past, secondary data collection required many hours of library research while now through the use of search engines vast amounts of information are available in short time.

- Accessibility. In the past, secondary data were often confined to libraries or particular institutions. The general public often did not have access to these collections. The Internet has been especially revolutionary in this sense. Having an Internet connection is frequently the only requirement to access these data. With a simple click, one can obtain vast amounts of information, but one must then discern whether the data are valid.

- Cost reduction. In general, secondary data is much less expensive than other methods of collecting data. One may analyze larger data sets, such as those collected by government surveys, at no additional cost.

- Breadth of research. The feasibility of both longitudinal and international comparative studies increases when one relies on secondary data. n the case of both longitudinal and international studies, research based on primary data alone often lacks the rigor that diverse social context comparisons require.

Despite the many advantages associated with the use of secondary data, there are some disadvantages.

- Inappropriateness of the data. Data collected by a researcher (primary data) are collected with a concrete idea in mind. In this way, secondary data sources may provide vast amounts of information, but quantity is not synonymous with appropriateness. Because secondary data were originally collected to answer a different research question or objective, such data may be inappropriate for a researcher's current.
- Lack of control over data quality. Government and other official institutions are often a guarantee of quality data, but this is not always the case. For this reason, when working with secondary data, quality must also be verified.

There are two possible paths to take when secondary data are deemed inappropriate: (1) answer the research question partially with the subsequent lack of validity; or (2) introduce an alternative technique of data collection, such as survey or data mining. In this work, despite the lack of some data associated with land occupation and population, we decided to make full use to secondary data. Due to the holistic character of the research it would have been difficult to use primary data only.

5.1.3 The proposed Grid

In Portugal, the territorial division for statistical purposes is based on NUTS (Nomenclature of Territorial Units for Statistical purposes), whose structure is broken down into three levels. NUTS I, covering the Mainland and the Autonomous Regions of the Azores and Madeira, NUTS II comprising 7 regions and NUTS III comprising 30 subregions. Each NUTS III is further divided according to the administrative divisions corresponding to municipalities and parishes.

For the sake of census operations, there is still a need to subdivide the Territory into smaller units, called statistical sections and subsections. The organization of this meshwork of territorial units gives place to the so-called Geographic Base of Reference of the Information (BGRI) that corresponds to the fundamental infrastructure of support to the realization and disclosure of the Censuses. However, such level of details proved to be still too low for a detailed study of the territory at municipal level. For this reason we decided to superimpose another territorial system, a grid of 100x100m, derived from the European statistical 1x1km grid (ETRS89 LAEA).

For purposes of European projects related to publishing statistical data on grids (e.g. the GEOSTAT project), the European Forum for Geography and Statistics created 1x1km grid datasets covering EU and EFTA countries. The grid coding is compliant with INSPIRE principles (Geographical Grid Systems specification).

The coordinate reference system is ETRS89 Lambert Azimuthal Equal-Area (EPSG: 3035, http://spatialreference.org/ref/epsg/etrs89-etrs-laea/). Separate datasets have been prepared for each country. Since it is encouraged to use this coordinate system and coding when disseminating statistical data on grids, we decided to use such system to use as the base for our territorial analysis.

For the effects of the current research, we created a custom grid 100x100m that directly derives from the 1x1km grid proposed by the European Forum for Geography and Statistics: it follows its orientation, as well as its reference system and projection. The aforementioned grid has been superimposed on the vector layer representing the Geographic Base of Reference of the Information subdivided into statistical subsections.

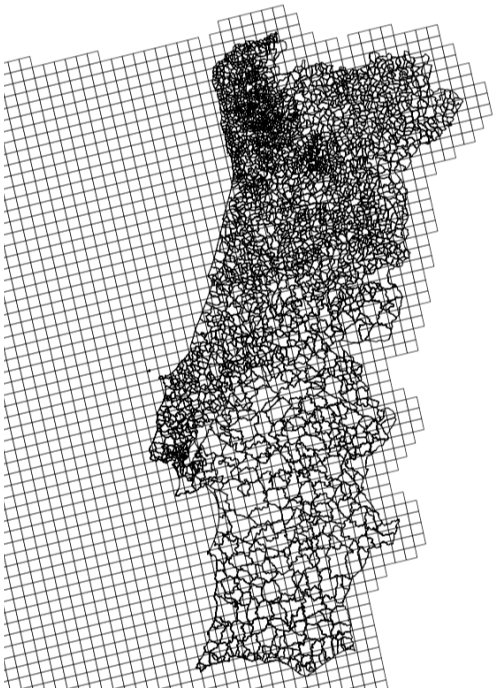

Figure 12 – CAOP Portugal 2017 overlayed on European Environmental Agency grid 10x10km (elaboration mine).

After having generated the 100x100m grid we proceeded by generating the centroids for each grid cell, with the intention of using the centroids for determining by spatial join which attribute the grid cell would have inherited from the subjacent statistical subsection. In a way, this constituted a trick to transfer information from the BGRI to the grid.

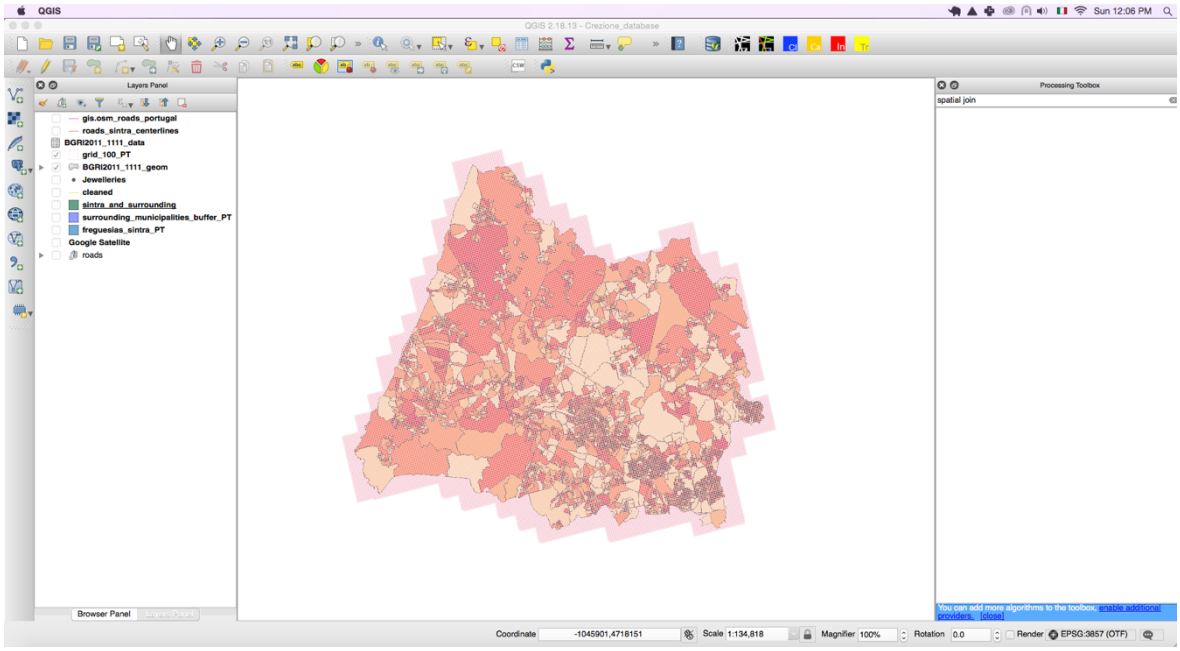

Figure 13 - The Qgis interface and the superimposition of the grid to the study area

In fact, by superimposing the two systems – the grid centroids and the BGRI – we managed to join attributes by location to the grid cells. In this way succeeded all the information contained in the BGRI to the centroid first, and then by means of join by ID (which is obviously the same) from the centroids to the corresponding grid cell.

In this way we managed to transfer all the information associated to the BGRI to a custom grid system that we chose to be in line with the European grid.

It is worth to notice here that also the INE has recently disclose a plan to work on a grid very much similar to the one proposed in this work for the next Census.

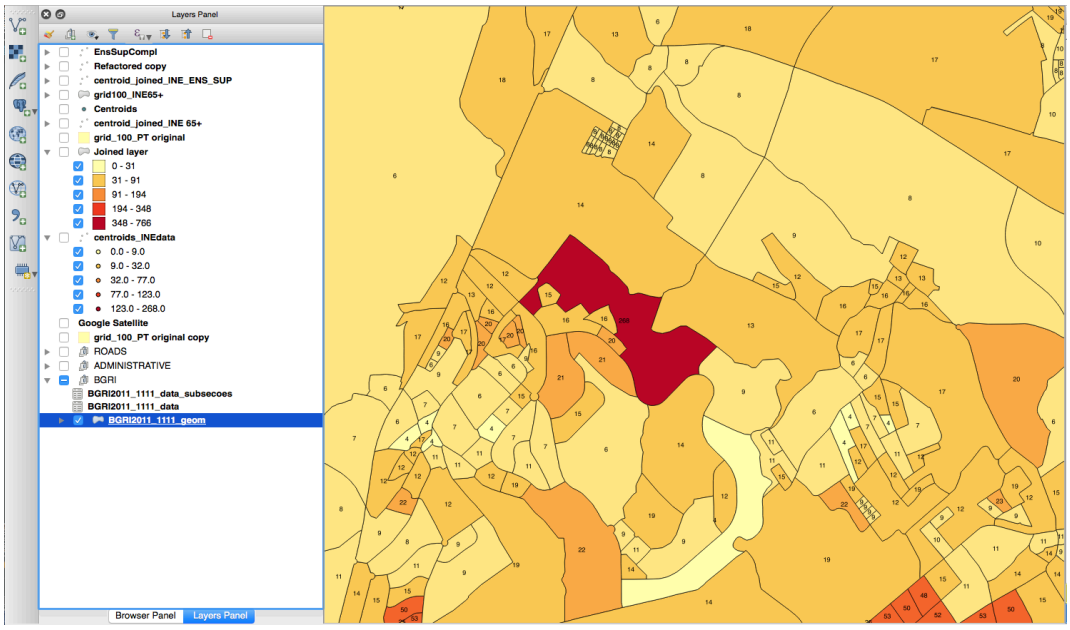

Figure 14 - Data aggregated by statistical subsection of the BGRI

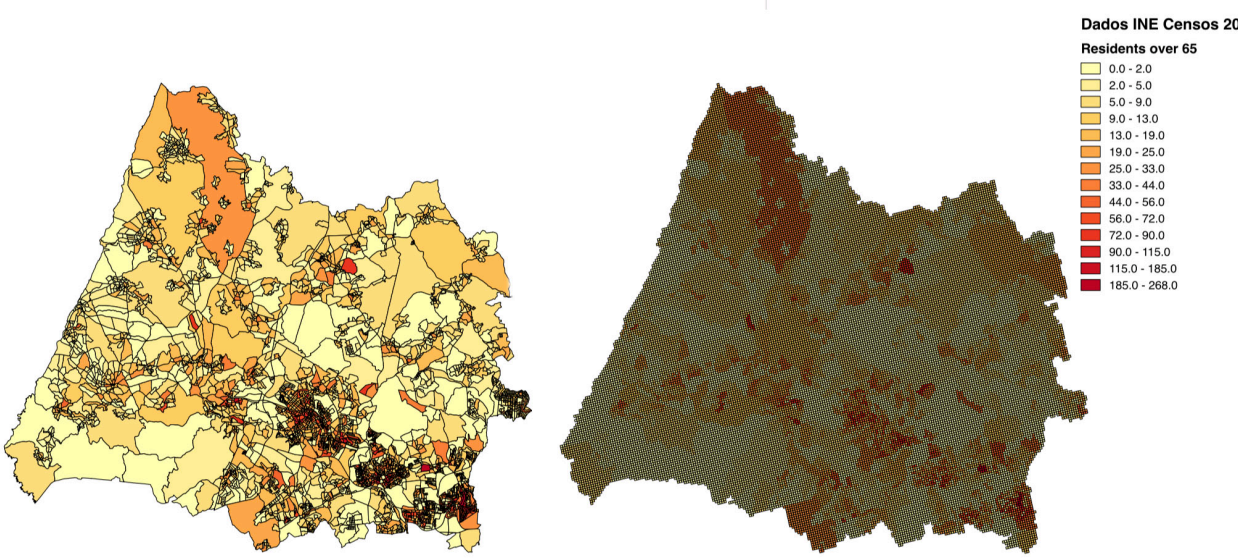

Figure 15 - Passing from a subsections system to the proposed grid system

5.1.4 Disaggregation of data

The Instituto Nacional de Estatística (INE) in Portugal establishes in its national system for geographic information. Such system is based on a geographic reference base called Base Geográfica de Referenciação da Informação, or BGRI. We took as a starting point for our data the BGRI of 2011 ("SNIG :: Base Geográfica de Referenciação da Informação 2011," n.d.), the one used for the latest national Census.

For the sake of the present research however the resolution proposed by the BGRI – the subsection level – was still considered to be too low. Therefore we decide to further disaggregate the data into a more refined system, our intention being the one of characterize with more detail the sometimes vast areas that the BGRI describes as single units but that could in some cases be constituted by a meshwork of different locations with different behaviors.

In order to perform such disaggregation of data we decided to take into account the buildings dataset provided by the municipality of Sintra. The rationale behind this choice has been weighting the values aggregated for the whole subsection by the amount of construction actually present on the 100x100m grid cell area. That means that if a grill cell contained one or more buildings, the values associated with the cell would have been multiplied by a factor representing the amount of construction of the grid cell. Such factor was resulting by the footprint of the building times the number of floor it featured.
Due to the lack of information in the dataset provided by the municipality of Sintra

about the number of floors, we had to find a way to calculate the number of floors by dividing the height of each building (a kind of information which we had) by 3 meters.

Prior to do that we also filtered the kind of information clearly erroneous such as building heights below 1 meter.

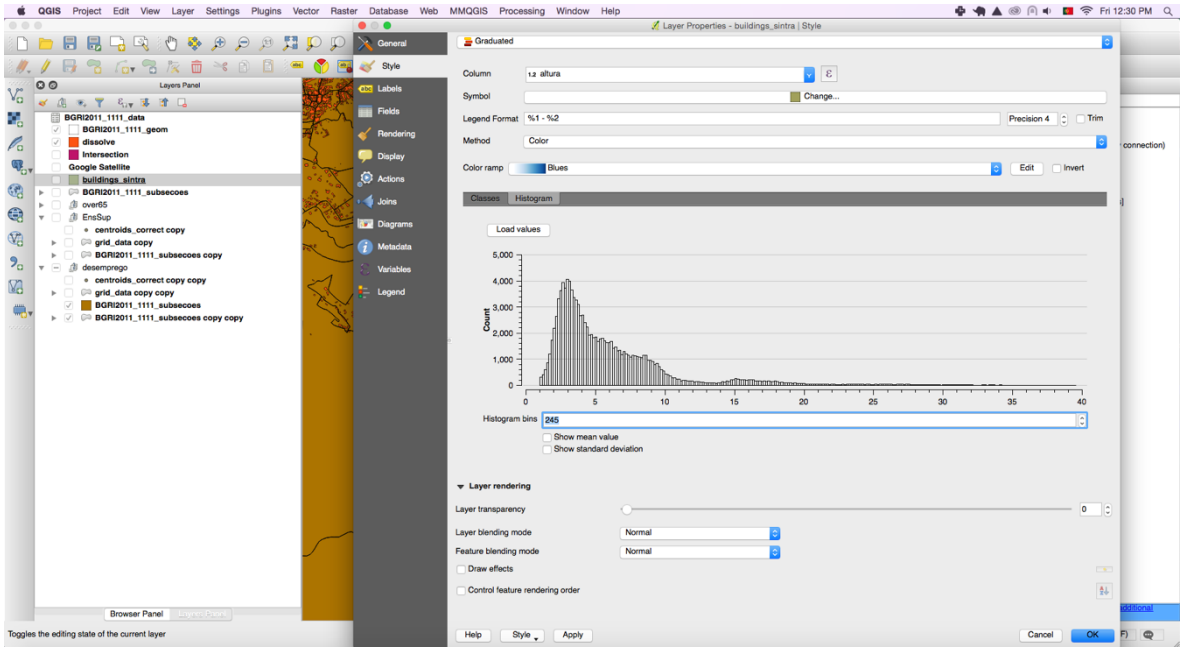

Figure 16 - Distribution analysis on building heights

We then considered all the building with height lower than 3 meter as having one floor, for the rest of the buildings their height has been divided by 3 to get an approximate number of floors.

After having calculated the number of floors for each building we went on calculating the exact portion of each building footprint that was contained in each grid cell. This with the intention of getting the exact amount of construction for each grid cell.

So the first question we had to answer here was how to calculate the total built area for each grid cell?

First of all, we want to intersect the buildings with the grid in order to split parts of buildings in their respective grid cell.

In order to do this, we created a new table “buildings_grid” including:

- the ID of each building

- the geometry of the intersection between building and grid

- the number of floors for each building

- the ID of the grid cell that contains the building or its part.

As a result of this operation, we get a table in which we can relate the split parts of the buildings with the relative grid cell.

Then we proceed to calculate the new attributes related to the split parts of the buildings (table “buildings_grid”).

To do that we created two news columns in the table “buildings_grid” :

-- building footprint (area de implantação)

-- building total built area (area de construção) obtained by multiplying the building footprint per the number of floors

We then got a table of the split parts of the buildings with all their related attributes and we want to aggregate all these attributes by grid cell.

In the table "grid_data” we therefore added and computed a few columns related to the

parts of buildings they contain:

permanentes_pisos_mean

permanentes_pisos_max

permanentes_area_implant

permanentes_area_constr

fator

And we grouped them by grid ID. In this way we got the total building footprint and building total built area per grid cell. Then, in order to determine how much how the built up area of each grid cell represents in terms of percentage to the total built up area of the containing subsection. This would have given us a factor that would represent of much the built up area of a specific grid cell would count within the containing subsection.

In order to do that we divided the building total built area of the grid cells by building total built area of the INE subsections.

The results is the factor that each grid cell expresses in terms of total built area in relation to the total of the subsection. Such factor would then become the fundamental variable to relate to when willing to disaggregate whatever Census data related to population and buildings to a higher resolution than the usual statistical subsections, getting up the individual grid cells proposed in this work.

So, if we want to know the value of each indicator weighted by the total built up area we just have to multiply the factor - obtained by dividing the building total built area (area de construção) of the GRID cells by buildings total built area (area de construção) of the INE subsection - times the given value of the INE subsection.

In this way we get the value of each indicator weighted by the total built up area of the specific grid cell.

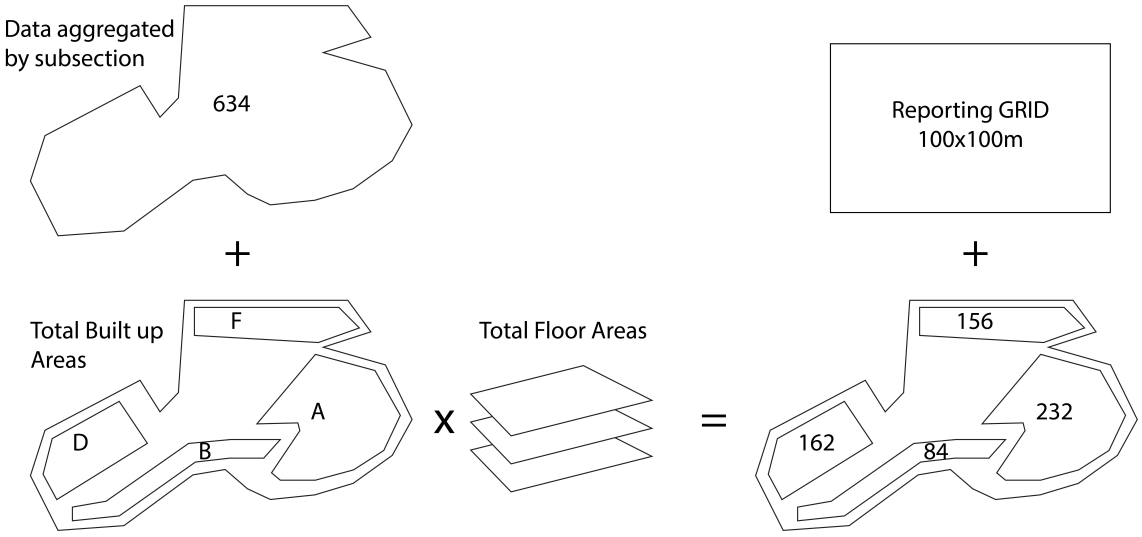

Figure 17 - A schematization of the disaggregation of data from BGRI to grid cell

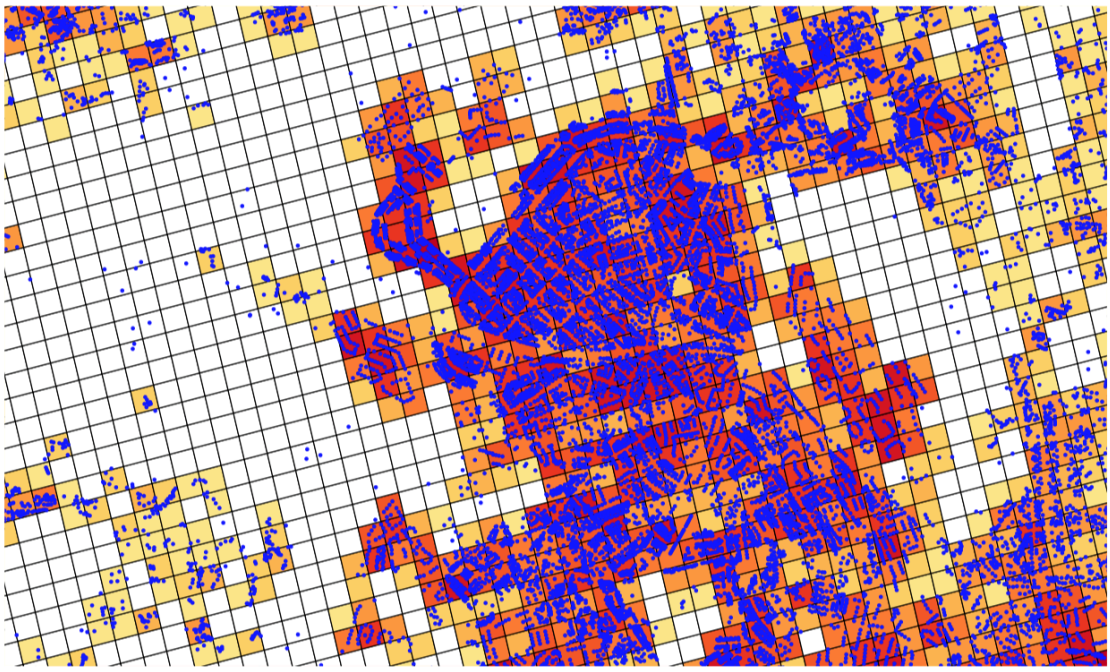

Figure 18 – The result of the disaggregation of data based on building intensity

In this way all the indicators related to the population and the buildings have been recalculated at the level of the grid cell, gaining a higher level of detail. It is more precisely a disaggregation of data previously aggregated at the level of the subsection and now aggregated at the much finer level of the grid cells. Such disaggregation in order to be as close as possible to the reality of territory has been based on the principle that the values of demographic indicators are linked to the presence of residential buildings (more building, bigger buildings, more people). Therefore the value of such indicator has been disaggregated by weighting the primary value by the amount of construction (footprint times number of floors) per each grid cell.

By doing this we succeeded in turning the meshwork of information about the territory much more refined, retaining a close link with the reality of the place.

5.1.5 Web scraping and geocoding of economic activities

In order to characterize the territory of Sintra municipality from the perspective of its economic activities and their distribution throughout Sinta's territory, we first needed to locate economic activities through the territory itself.

Due to the lack of quality data about economic activities distribution on the territory of Sintra, we decided to collect data from the web by web scraping.

We previously assessed the validity of a few datasets provided by the Municipality of Sintra on economic activities. Unfortunately the provided data were not sufficient for the degree of detail we intended to work with. For the kind of analyses we intended to do on the distribution of Sintra's economic activities, a comprehensive dataset of georeferenced points of economic activities was needed. So we opted to work on primary data instead of secondary data and decided to employ an alternative method to gather an original set of data, sufficient for the scope and the degree of detail of our research.

A total of 17.000 georeferenced points of economic activities was collected for this task. Such collection of data has been performed by means of web scraping: web scraping, or web data extraction is data scraping used for extracting data from websites. In fact, it is possible to extract a wealth of useful data about the economic activities in a territory by means of web scraping. The content of the web page may be parsed, searched, reformatted, its data copied into a spreadsheet.
In this case we were looking for Sintra's companies names, activity types and addresses to study the distribution of such economic activities over the territory. To do so, we implemented an Application Programming Interface (API) capable to extract data from a given web site. We then selected a list of websites that contained information about companies for the whole country.

The web-scraping operation enabled to extract from a number of publicly-available webpages name, address and typology of specific economic activities. Then such information has been used to feed a database that later on by means of geocoding served to geolocate such locations on the map.

While web scraping can be done manually, we opted for an automated process implemented using an API. The selected data (company name, activity type and address) was gathered and copied then from the web to a JavaScript Object Notation (JSON) file, for later retrieval.

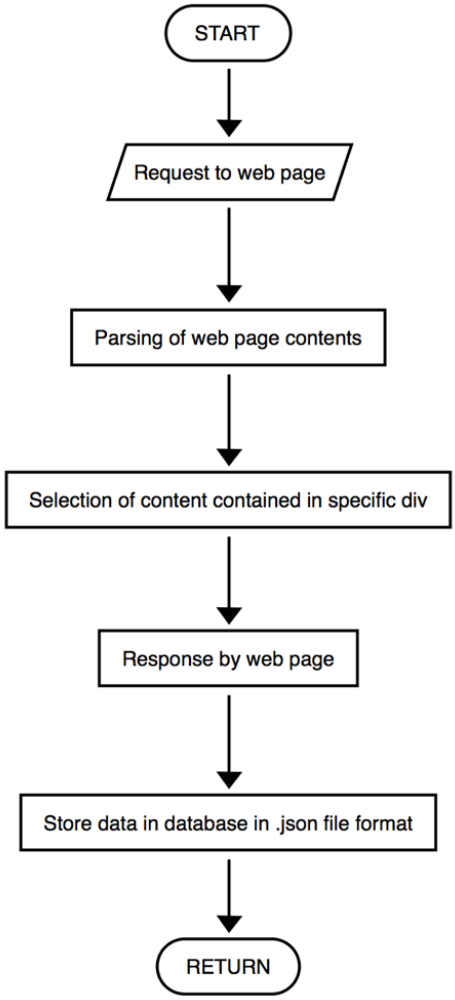

Figure 19 - Webscraping algorithm

Such data constituted the basis for the subsequent step – the geocoding of the retrieved companies' addresses.

Geocoding, in fact, is the process of transforming a description of a location—such as an address, or a name of a place—to a set of geographic coordinates on the Earth's surface.

Such operation that has the potential to become cumbersome if performed on a large scale – such as the scale of Sintra's territory – can be automated by means of online database services, as the ones provided by Google - that we used in this work. That means that by querying to the online service provided by Google we were able to

translate the 17.000 addresses we got from the web scraping of business activities located in this area.

Google Maps Platform, in fact, provides a Geocoding API that can be accessed through an HTTP interface. Client libraries make developing with the Google Maps web service APIs much easier by providing native implementations of common tasks, such as authentication, request throttling and automatic retry. This has been the solution chosen to perform the current task.

The resulting locations are output as geographic features together with attributes gathered in the web scraping phase (name and type of activity), which was later used for mapping or spatial analysis.

The results from such Geocoding has been stored in a table in Comma Separated Values (.csv) file format. At this point we could finally import the table to Qgis – not before erasing the field with the businesses names, for privacy reasons. During the importing phase we also had to declare in the Qgis importing prompt which field in the table represented longitude and which represented latitude.

Afterwards, as we got all the points of the business activities located on the map, we were finally able to run the analyses for which those points were needed.

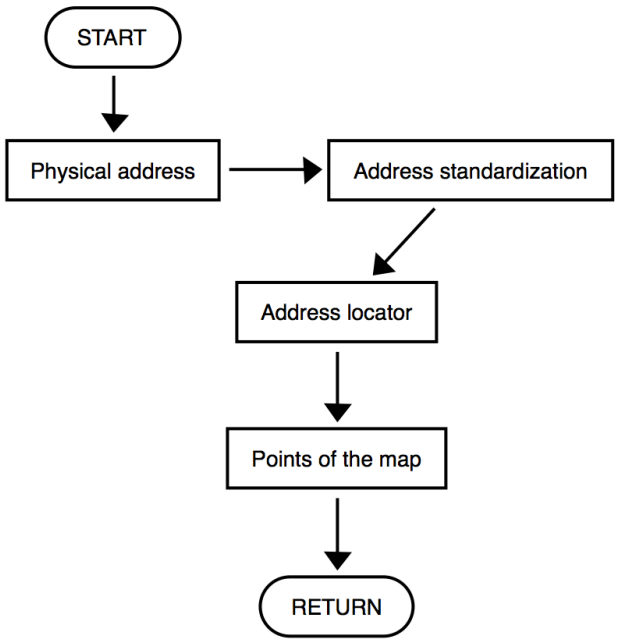

Figure 20 - Geocoding algorithm

5.1.6 Normalization phase

In order to make the different indicators comparable between each other and ready to use in operations such as averages, we decided to either normalize all the values from different indicators or to use shares – when possible – instead of absolute values.

In order to perform such normalization, the following formula has been employed:

$$z = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Equation 1 - Normalizing expression

Such normalization takes place in the Field Calculator and involves the creation of a new field in the table of the grid data while the normalization of the original data is performed by a simple query that translates the generic formula above.

This method has been used for several indicators, the ones for which it made sense to be expressed in terms of normalized values, while for the ones for which a share expression was more relevant, we decided to transpose them into shared values. In this case the expression we used in the Field Calculator was even simpler involving a ratio between the actual value and the total of the given dimension – as in this case the ratio between the number of people with higher degree education and the total of the resident population.

5.1.7 Urban Atlas

In order to map the different land cover units of the territory of Sintra we recurred to the already existing dataset of the European Copernicus project Urban Atlas.

The Urban Atlas offers a high-resolution land use map of the major urban areas across Europe, adapted to the European needs as discussed and agreed with DG Regional Policy.

The Areas of Interest for Urban Atlas Mapping are determined by DG Regional Policy. The Urban Atlas contains information that can be derived mainly from Earth Observation (EO) data backed by other reference data, such as COTS navigation data and topographic maps.

Input data sources are:

- Earth Observation (EO) data with 2.5 m spatial resolution multispectral or pan-sharpened (multispectral merged with panchromatic) data.

- Topographic Maps at a scale of 1: 50 000 or larger.

- COTS navigation data for the road network.

- Sealing layer based on FTS specifications for degree of sealing for level 3 classes .

Ancillary data required for certain classes may include:

- Local zoning data (e.g. cadastral data).

- Field check (on-site visit).

- Very high resolution imagery (better than 1 m ground resolution, e.g. aerial photographs).

It is easy to understand that the Urban Atlas mapping has the potential of being by far more accurate than any other survey or territorial analysis to determine the composition of the land cover that could have been done in the context of this work. It is therefore used as secondary data in this work in order to double check the results of the territorial analysis performed on the data available for the present work.

Our preoccupation here has been to translate the typical Urban Atlas maps into our custom reporting grid system. In order to do so we disaggregated the data initially aggregated by Urban Atlas category and aggregated them at the grid cell level following the method illustrated in paragraph 5.1.4.

Some of this categories, aggregated at grid cell level, have been later used in the task of spatialization of specific SWOT analysis items, as fully illustrated in the next chapter.

5.2 Demographic indicators analysis

The choice for the anlysis of the demographic dimension of the territorial trends of Sintra has been one dictated by the notion that the human capital is key to a successful and socially sustainable development of Sintra’s system. In order to take into account Sintra’s human capital into our analyses we looked at both demographic groups distributions as well as housing trends. In the following paragraphs we will illustrate the methods that led to the calculation of all the territorial indicators connected with this dimension.

5.2.1 Population having completed at least secondary education

For example, in order to calculate the number of residents for each grid cell that completed at least the seconday education (meaning that they reached education levels ISCED 5-8), we multiplied the original values of total number of residents that completed at least secondary education per subsection (as by INE Census) for the factor that we already calculated for each specific grid cell. In this way we disaggregate the data by weighting the original values by the amount of residential construction in the grid cell.

In the grid_data table in SQL it would translate into:

"data_N_INDIVIDUOS_ENSIN_COMP_SUP" * "fator"

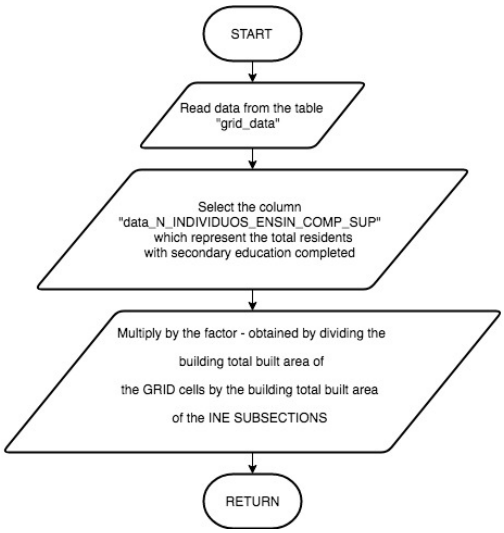

Figure 21 - Diagram of calculation for the value of population with secondary education completed

In this way it is possible to disaggregated the data from the INE previously aggregated by statistical subsection into the much more refined resolution of our custom 100x100m reporting grid.

5.2.2 Population over 65 years old

Similar to what we saw for the previous indicator, we disaggregate the data about the total population over 65 years old by multiplicate this figure by the factor previously calculated. The expression in the grid_data table in SQL would translate into:

"data_N_INDIVIDUOS_RESIDENT_65" * "fator"

In this way we get the total number of residents over 65 yeard old divided by grid cell.

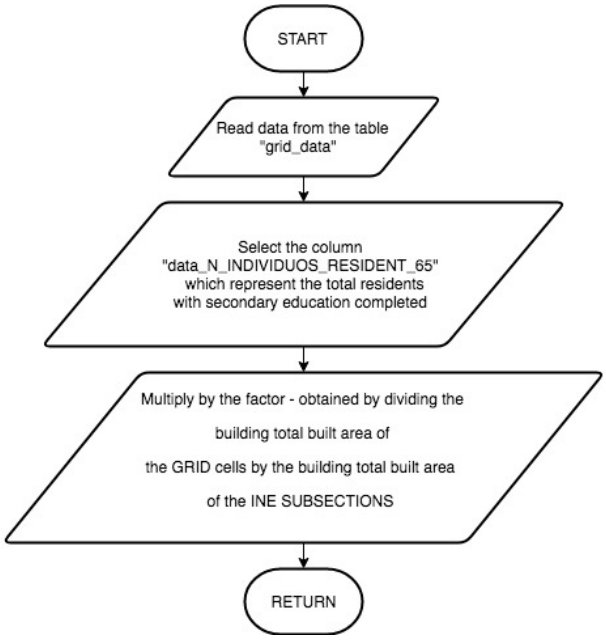

Figure 22 - Diagram of the calculation for the population over 65 years old

5.2.3 New dwellings 1991-2011

In the case of the new dwellings indicator we decided to consider as new the ones built in the timeframe 1996-2011 which corresponds to the data collected by the last Census of the INE. First of all, in order to calculate the value of this indicator, the total number of buildings for each grid cell (aggregated by subsection) is needed. To do that it is necessary to sum all the types of buildings, that are presented by the INE separately, together. Then we divide the number of the new buildings (1996-2011) by the total number of buildings for each grid cell (aggregated by subsection). In this way we get a factor representing the share of new buildings over the total of buildings. Then it is necessary to multiply the number of buildings for each grid cell ("permanentes_count") by this newly calculated factor. In this way we get the absolute number of new

buildings for each cell.

In this work we further refined the present indicator in order to get first the normalized value of it, and then the share value – which is the one that we later used for the territorial profiling calculations.

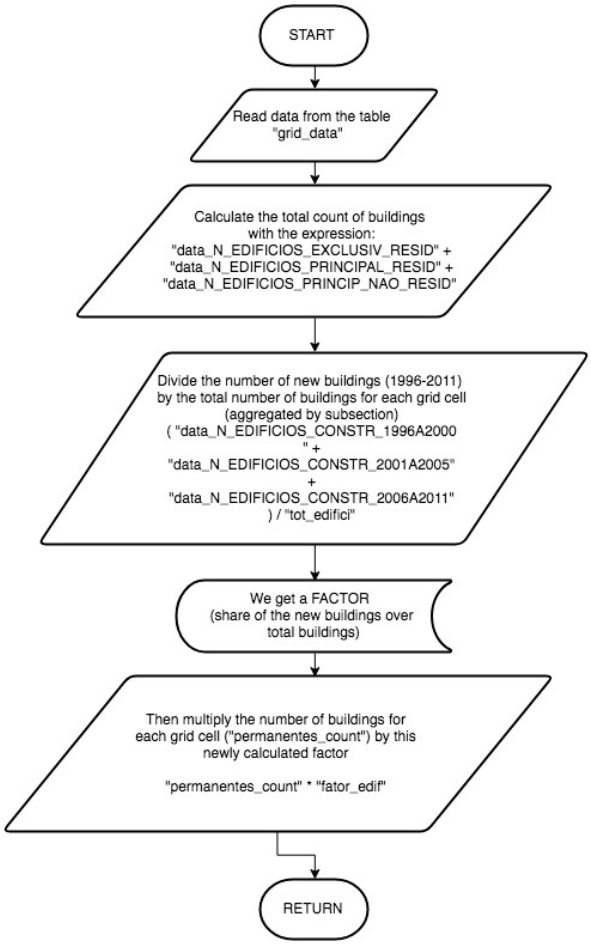

Figure 23 - New dwellings indicator algorithm

5.2.4 Unemployed looking for a job

In the same way that we saw for the Population having completed at least secondary education and the Population over years old indicators, we disaggregate the data about the population unemployed looking for a job by multiplicating this figure by the demographic factor previously calculated.

The expression in the grid_data table in SQL would translate into:

"data_N_INDIVIDUOS_DESEMP_PROC" * "fator"

In this way we get the total number of residents unemployed looking for a job divided by grid cell.

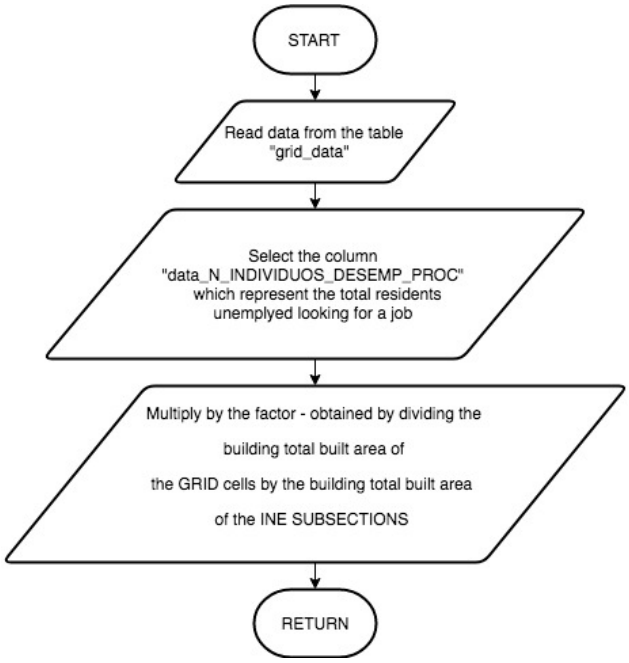

Figure 24 - Unemployed population looking for a job indicator algorithm

5.3 Occupation indicators analyses

What we called occupation indicators is a set of indicators that gives us a picture of how the territory in occupied and urbanized. They are all indicators that in a way or another measure densities: it can be population density or building density or analyses of urban dispersion. Such indicators are pivotal in a wok like ours, focused on issues related with urban dispersion and re-urbanization. The concentration of people and buildings on a territory determines its potential for development scenarios.

By dividing the values aggregated by statistical subsections in the the INE's BGRI

5.3.1 Population density

We include this indicator in the occupation dimension because, in our view and terminology, is an indicator of density and therefore it gives an idea about how the territory is occupied.

This indicator is a direct result of the disaggregation of data that we performed on the datasets of the last Census by the INE. The disaggregation process in summary takes the values of the subsections of the BGRI and divides them by total built surface that we have on each subsection. The total built surface is obtained by multiplying the floor area of each building by the number of floors and summing the resulting values for the whole subsection. At this point reporting grid 100x100m comes into play and by superimposing it to the buildings' map with the total built areas already calculated we can manage to transfer this data to the grid, successfully disaggregating the data aggregated at BGRI level with the INE and aggregating them at the custom reporting grid level. This is how the population density, for example, is calculated. In fact, each

grid cell in our reporting 100x100m grid represents one hectare. So, in this way we get to know for each individual location in the 100x100 reporting grid what is the population value by hectare.

5.3.2 Gross Space Index

The Gross Space Index – or GSI – is a common density indicator used to measure built-up areas density. The study of built-up density here is motivated by the desire to bring density into the equation of territorial profiling and the potential for re-urbanization analyzing the link between density indicators and urban performances.

Following the theory of Space Matrix by Meta Berghauser Pont and Per Haupt – firstly illustrated in the doctoral thesis Space, Density and Urban Form (2009) – we decided to explore the relation between total land coverage, GSI, with another indicator that measured the intensity of the land occupation, the Floor Space Index, or FSI. In fact, the Space Matrix theory is aimed at understanding the relational logic between density, urban form and performance. To do that different density indicators are related one to another in order to get to a more precise notion of how density and urban form work together. This work was ultimately aimed exploring the potential of urban density as a tool for urban planning and design, making density indicators more operationalizable tools for planners. It is in this perspective that we decided to adopt such stance and to make use of their method.

In order to correlate land coverage with building intensity we made use of two classic density indicators, widely employed in the Space Matrix theory: the Gross Space Index and the Floor Space Index. In our analyses we mainly employed the GSI, but kept the option of using the FSI for comparison and for extracting valuable insights about the relation between building intensity and urban compactness/dispersion.

So, the Gross Space Index or coverage, demonstrates the relationship between built and non-built space and is calculated as follows:

GSI=footprint of (m2) / area of aggregation (m2)

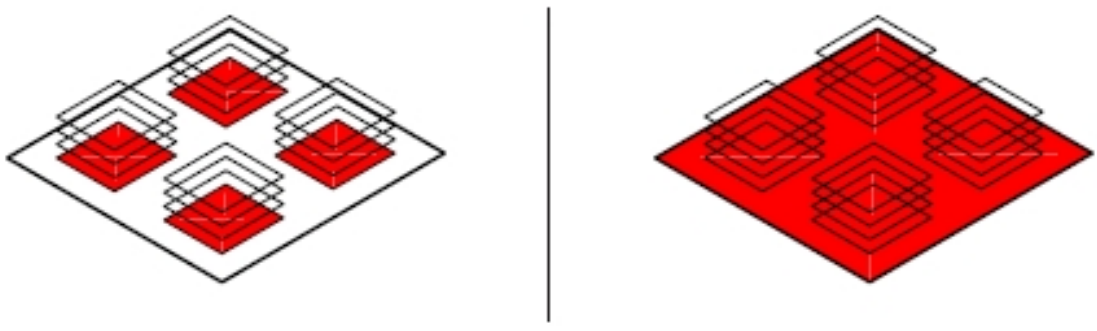

Figure 25 - Gross Space Index conceptualization (source: Berghauser Pont & Haupt, 2009)

In order to calculate the value of GSI for each grid cell we worked directly on the GIS layer containing all the data relative to the grid (the table “grid_data”) with the intention of creating a new field into which store all the results of such calculation of the GSI index.

To do so, we used QGis field calculator and created a new field called “GSI”. Subsequently, we selected from the table “grid_data” the column "permanentes_area_implant" which represents the total footprints of all the buildings in each grid cell. Then, we divided the values of "permanentes_area_implant" by the area of the grid cell, which is a standard 10.000m2 – resulting from the grid cells being 100x100m.

In this way we get the correct GSI values for each grid cell.

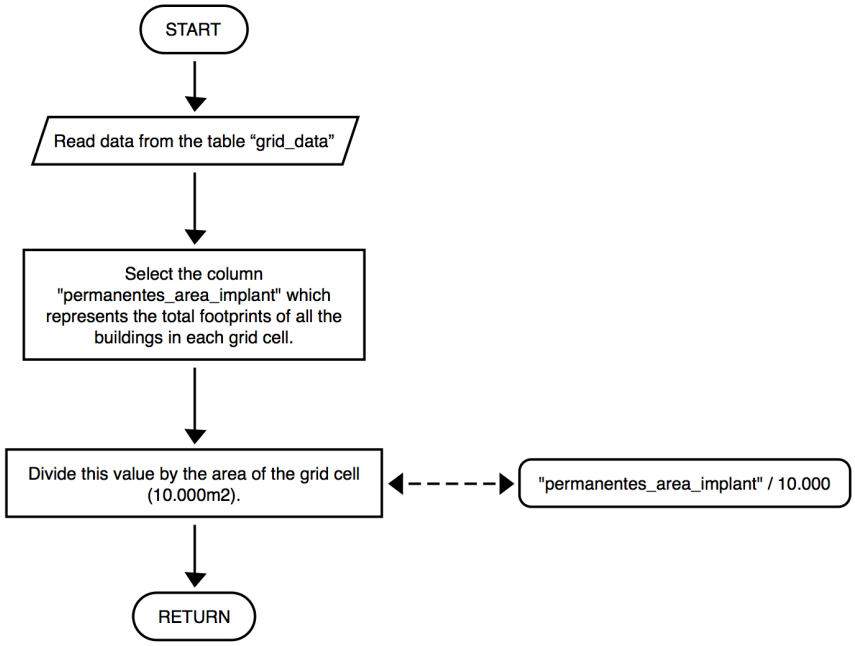

Figure 26 - GSI calculation algorithm

On the other hand, the Floor Space Index expresses the built intensity of an area. It represents the total floor areas of the counting all the buildings’ floors.

FSI = gross floor area / plan area

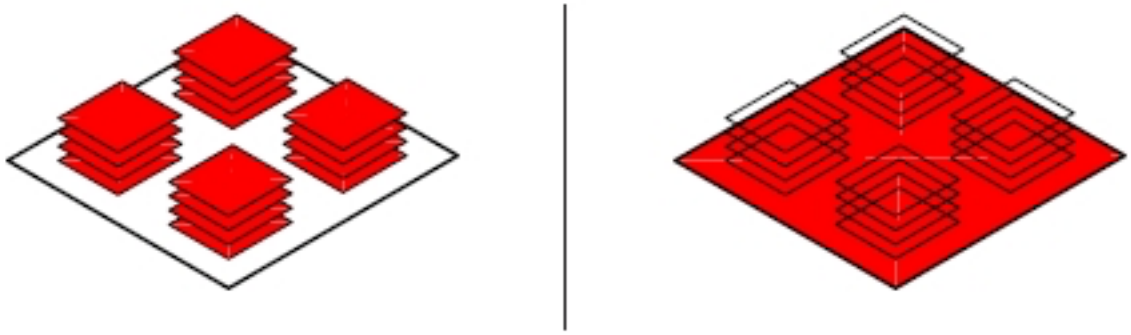

Figure 27 - Floor Space Index conceptualization (source: Berghauser Pont & Haupt, 2009)

In order to calculate the value of FSI for each grid cell we worked again directly on the same GIS layer we used to calculate the GSI values, containing all the data relative to the grid (the table “grid_data”). Again we created a new field to store all the results of the calculation of the FSI index.

To do so, we used QGis field calculator and created a new field called “FSI”. Subsequently, we selected from the table “grid_data” the column "permanentes_area_constr" which represents the total floor areas of all the floors of all the buildings contained in each grid cell. Then, we divided the values of "permanentes_area_constr" by the area of the grid cell, which is a standard 10.000m2 resulting from the grid cells being 100x100m.

In this way we get the correct FSI values for each grid cell.

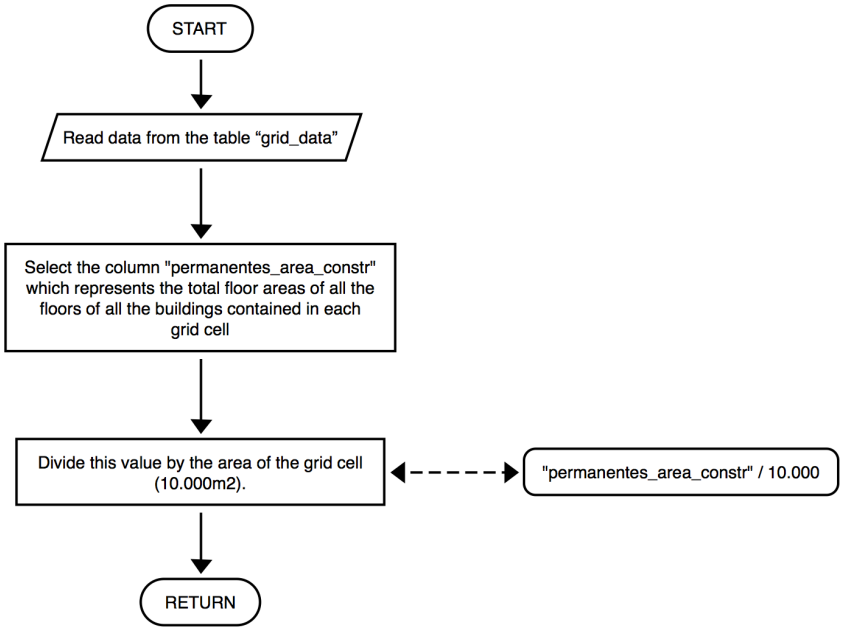

Figure 28 - FSI calculation algorithm

5.3.3 Dispersion Index

When looking at how to calculate the different degrees of dispersion for Sintra’s territory we started from evaluating many hypotheses and many methods to analyze the territorial dispersion patterns and intensities, subsequently narrowing down the choice to one method that proved to fit best our needs. The chosen method therefore consisted of the analysis of the continuity and compacity of what we defined as the buildings’ clusters.

Here, we decided to perform the main part of the operations by means of SQL coding directly in the PostGis database. This due to limitations of the Qgis software itself in calculating a few operations crucial to the dispersion analysis. In fact, the method we chose for determining the level of dispersion of each location in the territory of Sintra has consisted in the definition of a series of buffers of different diameters generated from the perimeter of each building in the territory.

Typically, a buffer operation is used when we want to create a new area around our object of interest. The buffer operation takes two parameters: a buffer distance and the object around which the buffer is to be created. In our case, we used this method to define the area of influence of each single building on the territory in order to be able to identify homogenous clusters of buildings over Sintra’s territory.

Regardless of the dimension of the input feature class (whether it is a point, line or polygon), the result of a regular buffer operation is always an area.

The buffer distance is usually applied to the outer boundary of the object to be buffered, in our case the perimeter of Sintra’s buildings.

Due to the fact that the analyzed features – the buildings of Sintra's territory - are at times packed closer to each other than the buffer distance between them, then the newly created buffer areas merge together. We then performed in these cases an operation of Dissolve in order to turn such overlapping buffer zones into one single entity, that we called building cluster. Such building cluster have been classified into three categories depending by the size of the radius of the buffer that generated the intersection of buffers in the first place.

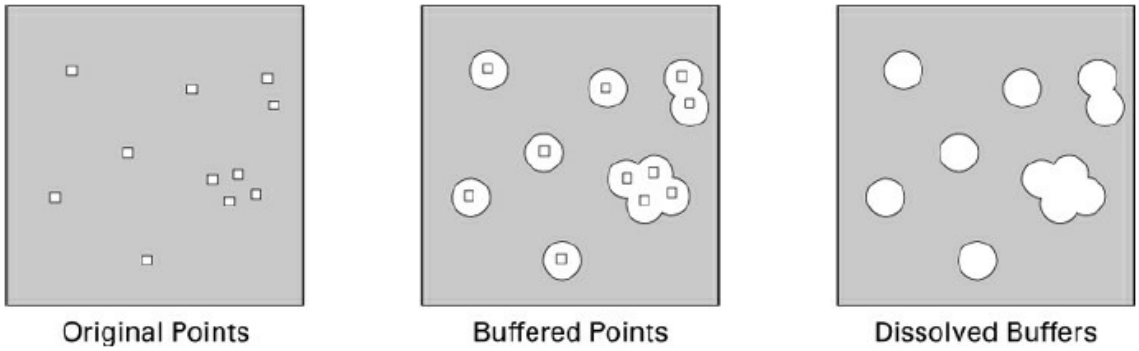

Figure 29 - The buffering and dissolving operations illustrated

The buffers' method we decided to use mimicked the method used by Jorge Carvalho in a famous work on the Portuguese dispersed territories topic (2013) where he proposed the use of a similar method consisting in the definition of clusters generated by the buffer zone around the buildings centroids of the analyzed territory. Such buffers intersecting with each other formed cluster at different scales, depending by the radius chosen for the buffering. The buffer radiuses that he proposed for such study of the dispersion of Ilhavo's territory were the following: 10m, 45m e 80m. Jorge Carvalho defined called these three buffers as "continuous", "dispersed" and "rarefied" conglomerates.

What we did in the present study has been, taking inspiration from Jorge Carvalho, trying to refine and further implement the buffer method proposed by him to study the Portuguese territorial dispersion.

In order to do this, we developed an algorithm capable of performing such buffer operations in sequence, increasing buffer size at each iteration of the process from 10m, to 45m and 80m - implemented in SQL code. Such SQL implementation proved to be much faster, more reliable and more robust than any attempt of implementing such algorithm we previously did in the Qgis software environment.

The result of such implementation has been the definition of different clusters, what we called *conjuntos*, resulting from the operation of Dissolve performed over the buildings perimeters buffers. Such *conjuntos* were also classified in four categories depending by the size of the buffer that formed then: "compact" for the *conjuntos* generated by the

buffers of 10m radius, “dispersed” for the *conjuntos* generated by the buffers of 45m radius, “rarefact” for the *conjuntos* generated by the buffers of 80m radius.

We then proceeded to transfer this information about the kind of cluster category of the the specific *conjunto* (compact, dispersed or rarefact) to the layer of the original buildings. This allowed us to associate this information directly to each building, so that we could see to which kind of cluster the specific building belonged. This by adding to the buildings table a new field with the attributes that identified of which “conjunto” the building was part of, if continuous, dispersed, rarefied, or isolated.

From this point on, our focus has been transferring this information about the degree of dispersion of a given cluster to the grid cells of our custom 100x100m grid. To do that, we decided to create a dispersion (or compacity) index that would reflect the different shares of clusters of each type for each grid cell.
To do that, we intersected the layer “conjuntos” with the grid (this would split the “conjuntos” in smaller parts cut by the grid), then we calculated the area of each of this parts and with the Qgis tool Group Stats we perfomed a sum of those areas of the resulting pieces of the original *conjuntos* grouped by cell id and type of *conjunto*. So as a result we got the total areas of each type of *conjunto* for each grid cell. This operation returned a Comma Separated Value file (.csv file format) without geometry that served to feed the following operation: the dispersion rating for each grid cell.

The result of such grouped stats was then used to define four new indicators that contained the information of the specific areas for each type of *conjunto* per grid cell. In order to match the id of each grid cell to the id of the CSV containing the *conjuntos* divided by type, we had to perform a Join operation between the CSV and the grid. Such Join operation however proved to have several instances on one side (the different types of *conjunto* referring to one grid cell of the CSV) referring to only one instance in the grid, the grid cell id. If the two layers would have had a spatial expression, it wouldn’t have been a problem to have a 1-to-many situation in the join – such is the case of Join by Location operation in Qgis that can relate several instances of one layer to only one in the target layer. However here the fact that one of the joining layer was simply a table without geometry made things more complicated. The solution here has been to filter the CSV sequentially for each type of *conjunto* getting therefore to a situation of 1 to 1 or 0 to 1 join between the elements contained in the CSV and the grid.

After this step, another important decision has been the one of determining how to aggregate the values for each individual grid cell. In fact, every cell could host different types of *conjunto* and the way we would have aggregate them into one single value per cell had to be carefully chosen. We decided to give a weight for each kind of *conjunto*: 4 to continuous, 3 to dispersed, 2 to rarefied, 1 to isolated conglomerates.

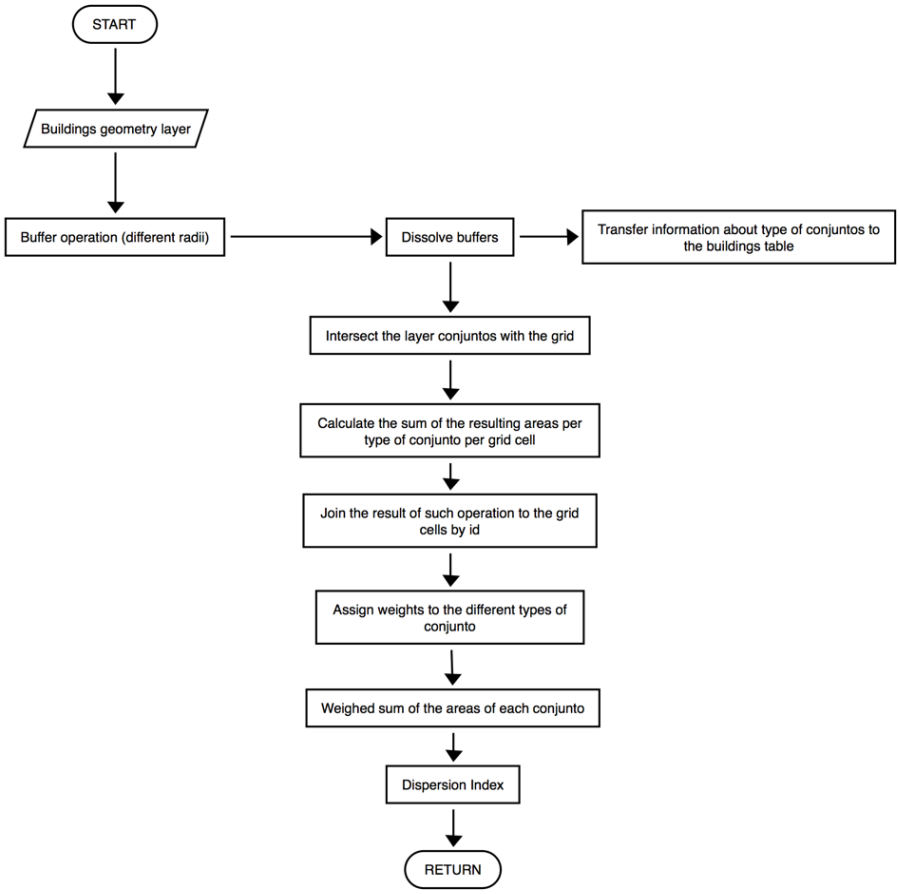

Figure 30 - Dispersion Index algorithm

So we simply performed a weighted sum of the areas of each conjunto multiplied by their respective weight. The result of such operation would be the dispersion index, where the higher the value the more compact the urbanization is and the lower it is the more rarefact the urbanization is.

The actual Sql query in the Field Calculator would look like this then:

(“continuo_share”*4)+(“disperso_share”*3)+(“rarefeito_share”*2)+
(“isolado_share”*1)

5.3.4 Empty dwellings

The indicator of the number of empty dwellings is included in the occupation dimension because we believe that it gives us a clear idea about the occupation trends of the territory: how the concentration of empty dwellings is distributed tells what are the areas with more demand for residential purpose.

This indicator is a direct result of the disaggregation of data that we performed on the datasets of the last Census by the INE.

5.4 Functions dimension indicators

5.4.1 Diversity Simpson index

First of all, we performed a count of the business locations points resulted from the geocoding phase within each grid cell. This allowed us to get a glimpse of the distribution of those locations throughout Sintra's territory. The final goal however more than just mapping the distribution of economic activities was to be able to calculate what we called the Diversity Index. Such indexes capable of measuring the land mixed use of a territory are a common practice in territorial analyses and planning. While there are different ways to measure rates of mixed use, we follow some of the concepts that evolved from the debate around mixed use and urban compactness (Manaugh & Kreider, 2013; Van Den Hoek, 2008).

Some theories also relates the mixed use index with neighborhood vibrancy (Yue et al., 2017) or with the concept of walkability (Brown et al., 2009). In this study we consider diversity as a measure of "urbanity"

While initially, we decided to employ a mixed use index, or MXI, essentially a ratio between the number of residents per grid cell (previously calculated) and the number of economic activities per grid cell, we later thought that it was too much of a simplistic way to look at the territorial functions diversity.

The method initially proposed represented the degree of mix of use between residential and "commercial" points within each cell. In the field calculator we expressed this in the following way:

"pop_ha" / "num_economic_activities"

Later, we decided to take into account the relevance of each specific economic sector on on each location within Sintra's territory, as opposed – and mixed – with the residential function, switching to a more refined way of calculating diversity employing a Simpson's Diversity Index.

So, for the sake of the study of such specific relevance of each economic, we conducted an analysis focused on calculating the ratio of each economic sector (1º, 2º, 3º) relative to all the others and the number of family nucleuses in the grid cell.

Firstly we calculated the share (or proportional abundance) of each "use" in the grid cell using the following formula (the full explanation of the process of calculating the number of activities per economic sector is explained in the paragraph 5.4.2):

"use_A_share" = use_A"/("use_A"+"use_B"+"use_C"+"use_D")

We then repeated such calculation for "use_B_share", "use_C_share" e "use_D_share"

Here’s how to the same exact query looked like in the Field Calculator of Qgis: "Count_sect_prim" / ("Count_sect_prim" + "Count_sect_sec" + "Count_sect_ter" + "tot_nucleos_fam")

After this we were able to calculate the diversity of the different economic activities or “uses” present on the territory by grid cell. To do this we chose to use a Simpson’s Diversity Index.

Simpson's Diversity Index (Simpson, 1949) is a common measure of diversity. The Simpson index was invented in 1949 by Edward H. Simpson to measure the degree of concentration when individuals are classified into types. The measure equals the probability that two entities taken at random from the dataset of interest represent the same type.

In ecology, it is often used to quantify the biodiversity of a habitat(Keylock, 2005; Leps, de Bello, Lavorel, & Berman, 2006; Nagendra, 2002). It takes into account the number of species present in the ecosystem, as well as the abundance of each species, analyzing therefore its richness and sustainability. Here it will quantity the diversity of economic activities ecosystem in Sintra.

Following here, in Equation 2, is the general Simpson’s Diversity formula, where R represents the richness of the system (the total number of types in the dataset).

$$\lambda = \sum_{i=1}^{R} p_i^2$$

{ lambda =\sum _{i=1}^{R}p_{i}^{2}}

Equation 2 - Simpson's Diversity formula

This equation is also equals to the weighted arithmetic mean of the proportional abundances pi of the types under analyses, with the proportional abundances themselves being used as the weights: this is the formula we decided to use here and to implement in our query.

So the general formula we used in this study is the following: ("use_A_share"*"use_A_share")+("use_B_share"*"use_B_share")+("use_C_share"*"use_C_share")+("use_D_share"*"use_D_share")

While the general formula looks like the one above, the actual query we use looks like the following:

("sect_1_share" * "sect_1_share")+

("sect_2_share" *" sect_2_share")+

("sect_3_share" * "sect_3_share")+

("nucleosfam_share" * "nucleosfam_share")

Where the proportional abundances of each type are weighted by themselves and the result used to form the arithmetical mean between all the proportional abundances. Proportional abundances are by definition shares values, so that means that are constrained to values between zero and one, but it is a weighted arithmetic mean, hence $\lambda \geq 1/R$, which is reached when all types are equally abundant.

Since mean proportional abundance of the types increases with decreasing number of types and increasing abundance of the most abundant type, λ obtains small values in datasets of high diversity and large values in datasets of low diversity.

Note that in this study we calculate the diversity index of the three economic sector plus the amount of households for each grid cell.

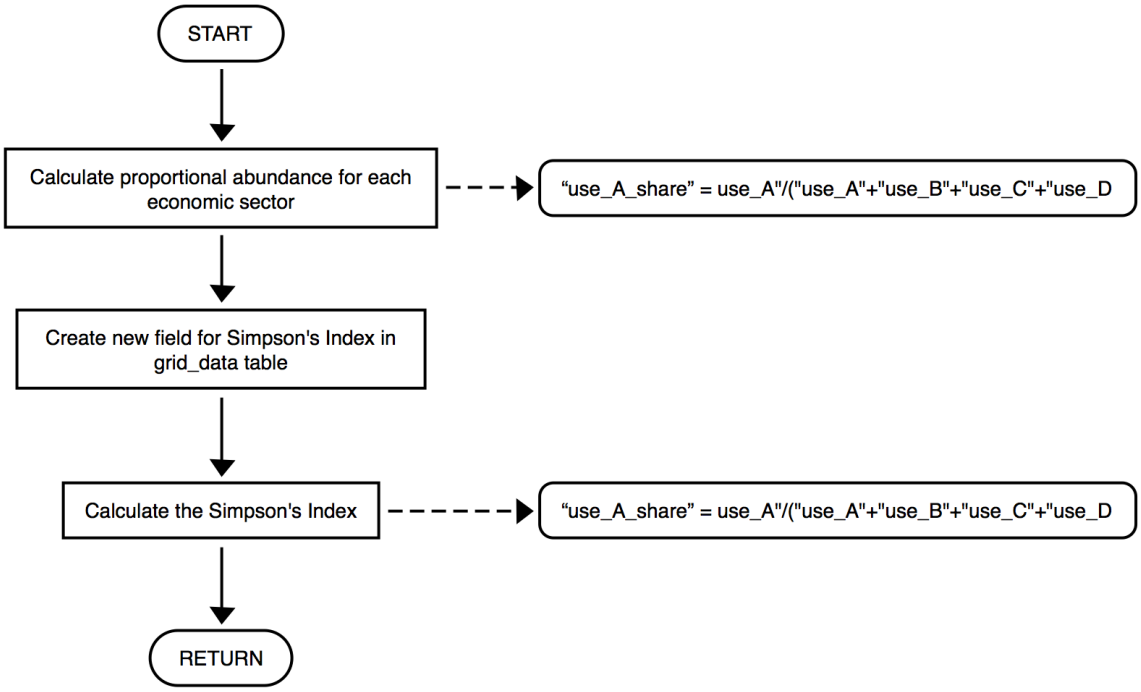

Figure 31 - Simpson's Index algorithm

5.4.2 Number of activities per economic sector

As we already saw in the previous paragraph, while initially we decided to employ a ratio between the number of residents and the number of economic activities per grid cell, we later decided that, in order to study the territorial dynamics of the economy of Sintra, an overview of the distribution of economic activities divided per economic sector was crucial.

Therefore instead of just using the total number of economic activities, we filtered the geolocated points resulting from the geocoding phase of the economic activities dataset by grouping activities type by sector (primary, secondary and tertiary).
The categories used for such classification by type of sector derived from the labelling created by the web sites from which the data has been extracted.

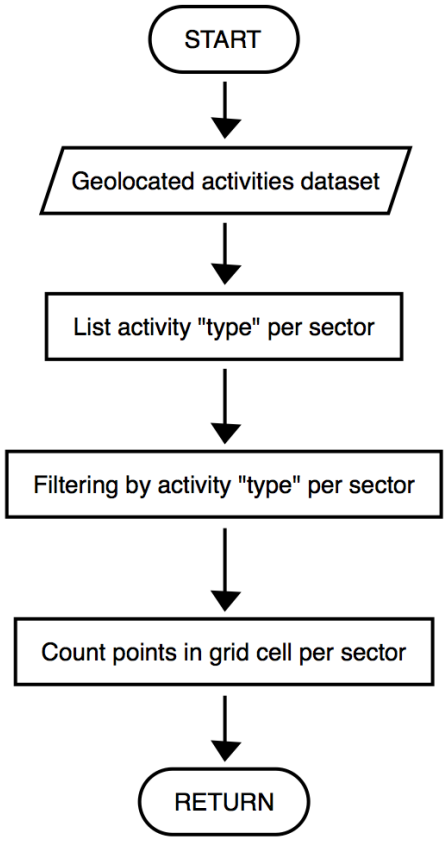

Figure 32 - Number of activities per sector algorithm

After having filtered the geolocated points of economic activities by economic sector, they have been transferred to the grid by means of count points in polygon GIS operation. In this way we obtained the number of activities per grid cell divided by economic sector.

5.5 Network dimension indicators

In order to do analyze Sintra's road network and to correctly link the results of such analyses to the proposed reporting grid a multi-step process and a custom workflow integrating GIS software and network analysis software was needed. Such workflow has been inspired by some seminal works on the topic by Jorge Gil (2014; 2015; Marshall, Gil, Kropf, Tomko, & Figueiredo, 2018).

5.5.1 Choice 5km radius

In order to perform the calculations of the Choice and Integration indicators of the network dimension, we employed a successor of the original Depthmap software (Turner, 2001, 2004) that originated by the work of the Space Syntax laboratory in London, the DepthmapXnet, as well the integrating module for GIS software developed by Jorge Gil (2015).

First of all, after having selected the dataset to work with – the Open Street Map center lines road network – we proceed to filter the road types relevant for this study. We concluded that paths and trails were to be filtered out from the original set. After this filtering, we then had to export the resulting road center lines network to DepthmapXnet software in .dxf format. As we opened it in DepthmapXnet we proceed on converting it to segment map, as stated by the Space Syntax theory for road center lines. Road center lines in fact are not treated as axial maps but rather as segment maps. After this setup process, the first analysis that we performed on the road network has been the Angular analysis with different radii including the choice measure in all of them. The chosen radii have been 400m, 1200, 5km, 15k. The choice of the radii depended by considerations made on the nature of the network as well as on the degree of accessibility by walking, by car on national roads and by car on highways.

After running the analyses in DepthmapXnet, we exported the results by Mapinfo file and imported them in Qgis.

At this stage we had to solve a critical problem in geographic reference system (CRS); after passing from DepthmapXnet to Qgis the layer lost the correct CRS so it had to be manually reset. After this we clipped the road network by matching to Sintra's administrational boundaries.

We then intersected the road center lines layer containing the space syntax analysis values with the proposed grid 100x100m. This operation splits the segments into smaller segments contained into one grid cell only at the time. Therefore we added a column with the updated length for each new segment of the road network as segmented by grid cell.

After this step, we were able to determine the weighted value of integration and choice for each new segment of the road network segmented by grid cell – such weighting has been then based on the segment length of the new segment multiplied by the integration or choice value that it sported.

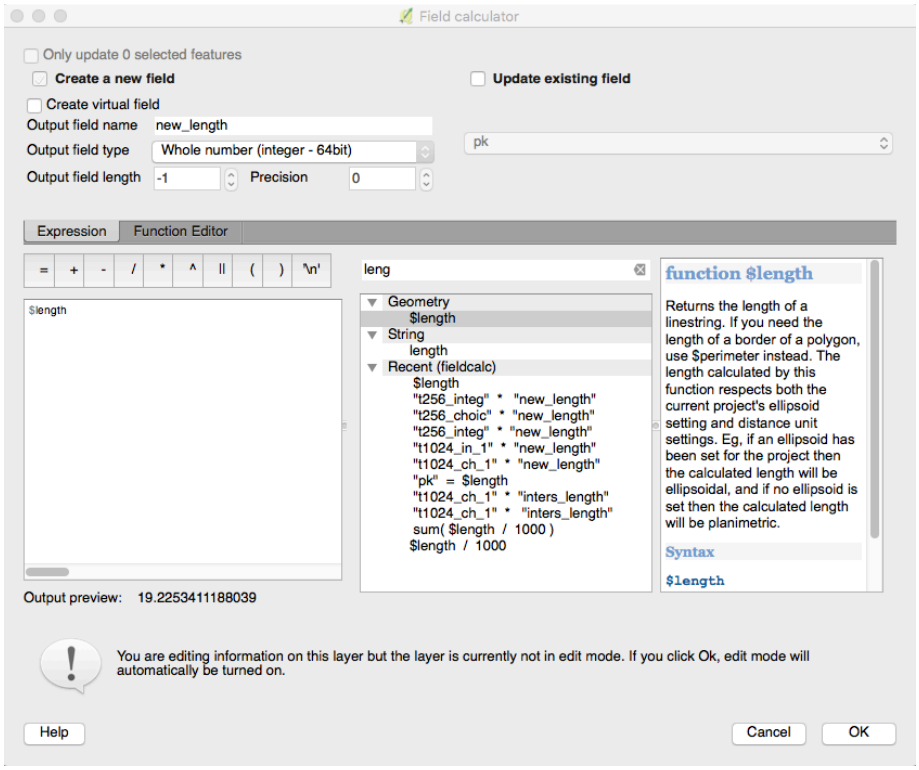

Figure 33 - Screenshot of calculating segment length for calculating each segment's relevance within each grid cell

In order to be able to calculate the new weight for each segment in the cell, we had then to sum the lengths of all the lines in each cell and divide the new length of each individual line by the result of such sum.

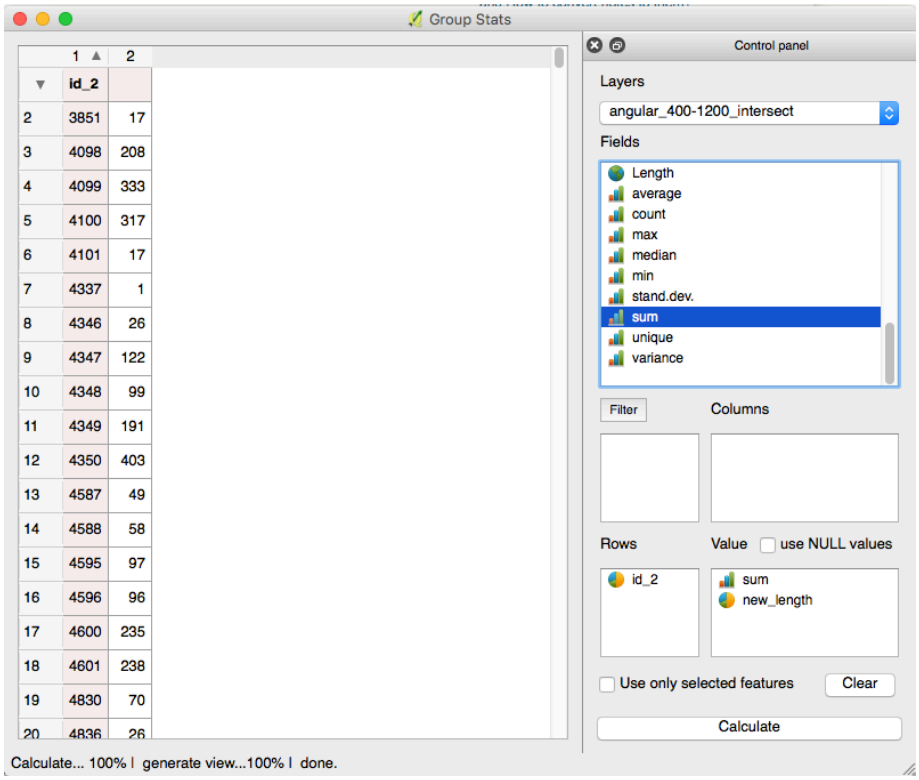

Figure 34 - Sum operation of the lenghts of all the lines in each cell

This ratio would give us a value between 0 and 1 that would represent the normalized weight of that line in the cell.

In the field calculator it would be:

"intersect_length" / sum("intersect_length", group_by:="id_2")

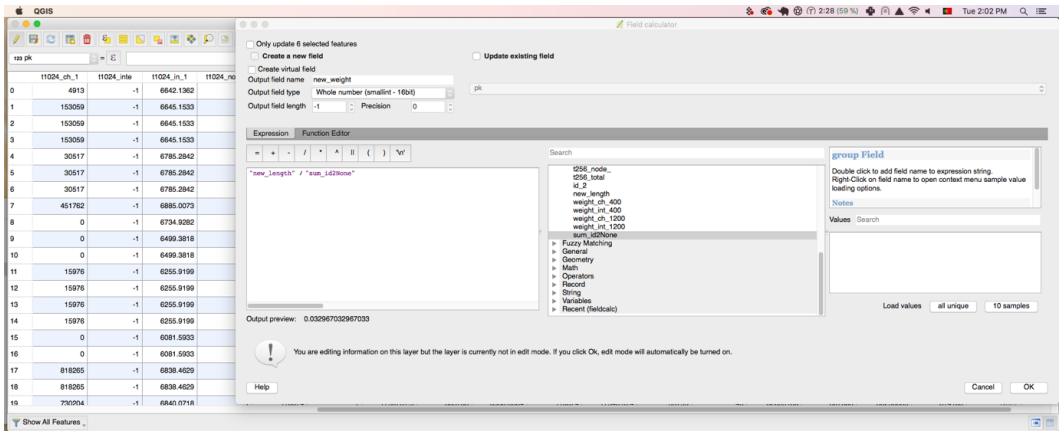

Figure 35 – Normalized weight of line in a cell

At this point we were able to create a column with the values of choice weighted to each segment of the road network.

In the field calculator it would be:

"choice" * "new_weight_norm"

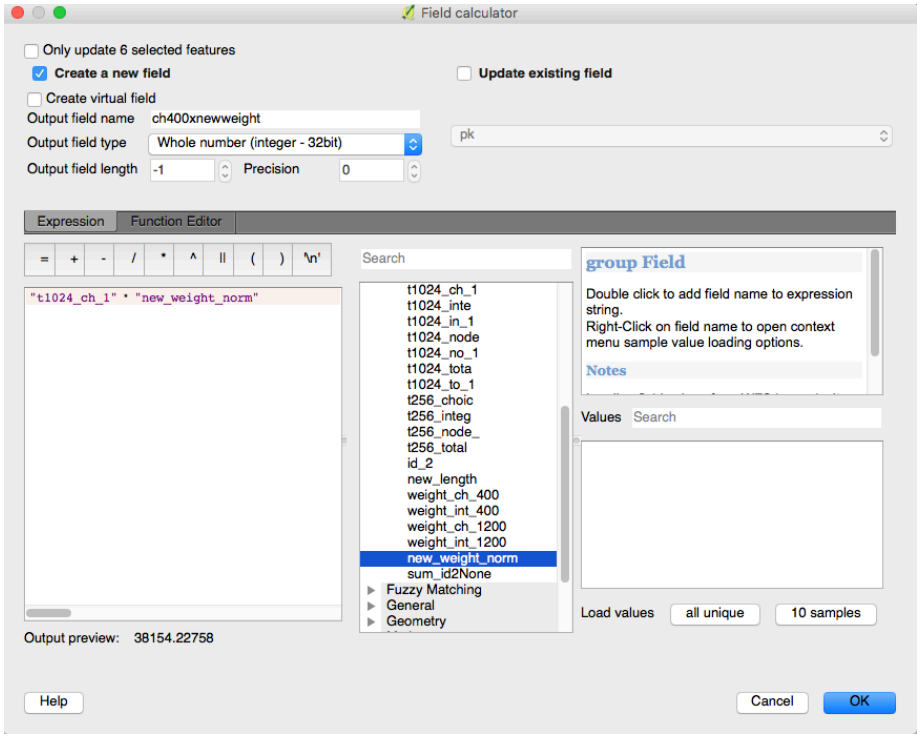

Figure 36 - Choice value weighted for each line in a cell

We then dissolved the segments by grid cell id and calculate a few stats for each: in this way we obtained choice values for each grid cell. To do so we used the plugin Dissolve with Stats in Qgis. What this operation does is returning one single value for each grid cell.

Choice must be first calculated by log10. For choice, we looked at maximum values. In the case of Choice, in fact, it is the maximum value that is passed to the grid layer.

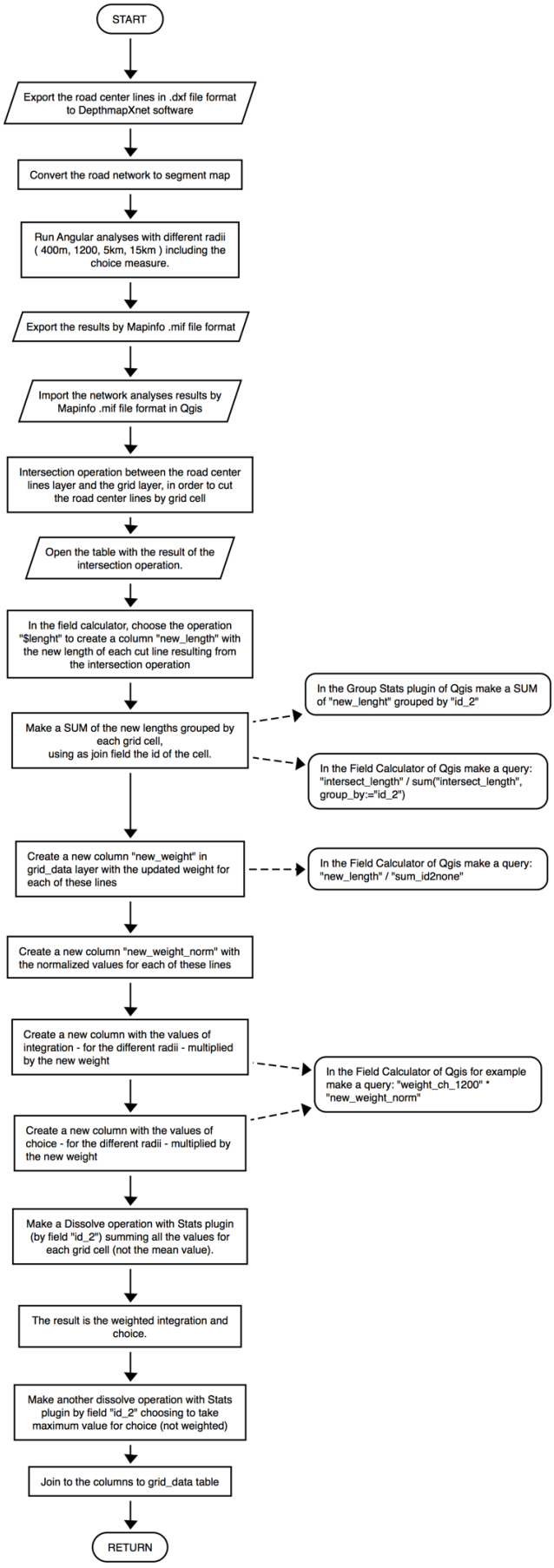

Figure 37 - Network analysis algorithm

5.5.2 Integration 5km radius

For the case of the indicator of Integration we follow the exact same procedure that we described in the previous paragraph for the indicator of Choice.

The only difference between Choice and Integration is the way how their values are calculated after the dissolve phase. What this operation of dissolving does is returning one single value for each grid cell. For the integration, contrary of what happens for choice indicators, it is necessary to look at the average values. It is the average value, in fact, that it is passed to the grid layer in the case of Integration.

5.5.3 Infrastructure density

We decided to look at infrastructure density as an indicator "network weight" for a specific area in the territory.

To do that we had to get back at the individual segment lengths that we already calculated to get to Choice and Integration indicators. With those segment lengths already line up we can then execute a sum of all the segments contained in each individual grid cell. What we get at the end is the total length of segments contained in a specific grid cell.

5.5.4 Number of culs-de-sac

In order to study the degree of segregation of specific areas in the territory of Sintra we decided to calculate the density of cul-de-sacs in Sintra's road network.
To do so, we decided to look at the segments in the road center lines network with choice value equal to zero. In this way we have been able to immediately detect what segments where actually cul-de-sacs. In fact, segments with choice value zero are cul-de-sacs by definition.

So we filtered all the segments with value of choice equals zero. Then by using the tool Join attributes by location we joined the segment layer with the grid layer and sum the number of segment with choice value that equals to zero within each grid cell. In this way we got a clear map of the most segregated bits of Sintra's road network, mapped on our custom reporting grid.

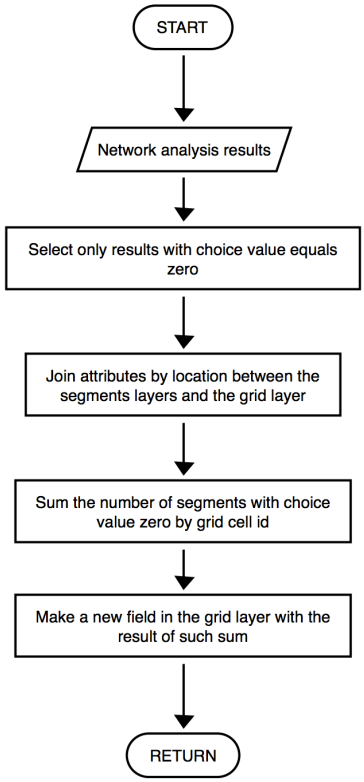

Figure 38 – Culs-de-sac indicator algorithm

5.6 Swot spatialization method

One of the applications of the proposed model that we presented in this work is the spatialization of a SWOT analysis.

Municipal and regional authorities were the first public entities in Portugal that, since the 1980s, have proposed the use of SWOT analyses as a framework for reflection on various development scenarios. Currently, SWOT analysis is used both as a component of planning practice and for the ex-ante evaluation of regional development programs.

However, even when SWOT analyses are employed to perform such ex-ante evaluations of regional development programs, they fail to capture the spatial character of such programs. This due to the fact that traditional SWOT analyses are rarely performed with a spatial point of view in mind. Hence, the need to find a novel set of methods capable of supporting what we called the spatialization of SWOT analyses.

In order to illustrate step-by-step how we “spatialized” the SWOT analysis proposed by the PDM of Sintra, it is important to notice that such SWOT spatialization has only been possible because of the territorial indicators already calculated. In fact, the basis for most of the SWOT analysis spatializations has been the territorial indicators presented in the previous paragraphs.

Occasionally we made use of additional indicators. This is the case of the Floor Space Index, already cited when talking about the Gross Space Index, used in the SWOT

spatialization to analyse the relation between land coverage and building intensity, or specific data extracted from the European Copernicus project Urban Atlas or even layers of information contained in Sintra's PDM.

Many items of the original SWOT analysis may not have a clear spatial expression, i.e. they may be of more strategic or normative nature, or they may be more vaguely related to the territory. For this reason, we selected a subset of the whole SWOT analysis items: we considered here the ones that had indeed a spatial expression and also for which we had sufficient data available.

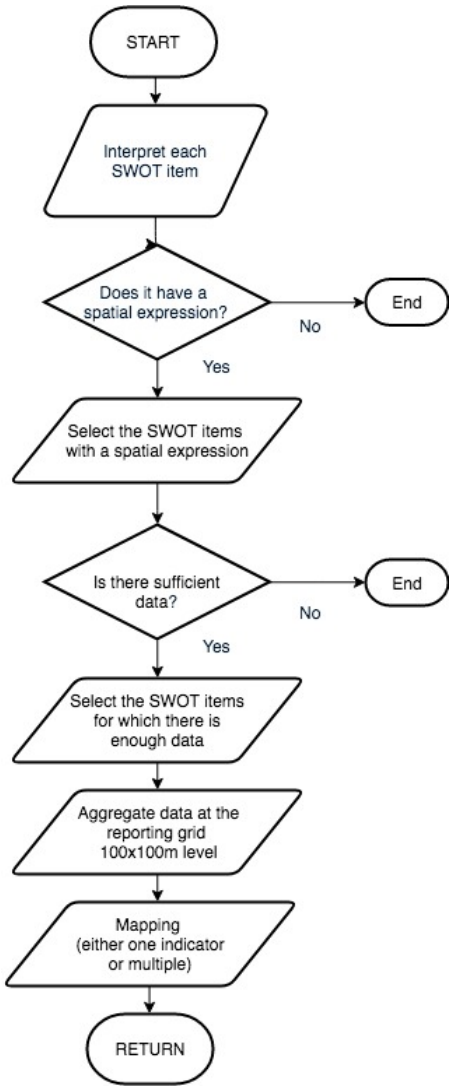

Figure 39 - SWOT spatialization algorithm

To get more in details of the actual process of SWOT spatialization, the steps are:

- Interpretation of each item in the SWOT analysis looking for a possible territorial expression.
- Check if sufficient data is available to perform an accurate mapping.

- Assess whether of not the specific SWOT item is better represented by just one indicator or by a comparison between different indicators or different datasets.
- Aggregate the data at the custom reporting grid level.
- Perform a thematic mapping highlighting the spatial expression of the specific SWOT item over the territory.

5.7 Territorial profiling

After having spatialized the SWOT analysis, we approach now the second application proposed for the model we developed in this work: the territorial profiling.

The territorial profiling is intended to highlight the inherent vocations of the different locations within Sintra's territory, by calculating the different values for a specific set of indicators under a specific set of filtering expressions.

The definition of territorial profiles within each scenario (here we only took into account one: the development of Sintra as a polycentric territory) involves the selection of the indicators that best fit the qualification of each profile / scenario and the weighting of the respective reference values and quantitative thresholds. Such choice was partly the result a literature research but mostly, due to the local character of the present work, an empirical fine-tuning of each reference value for each indicator.

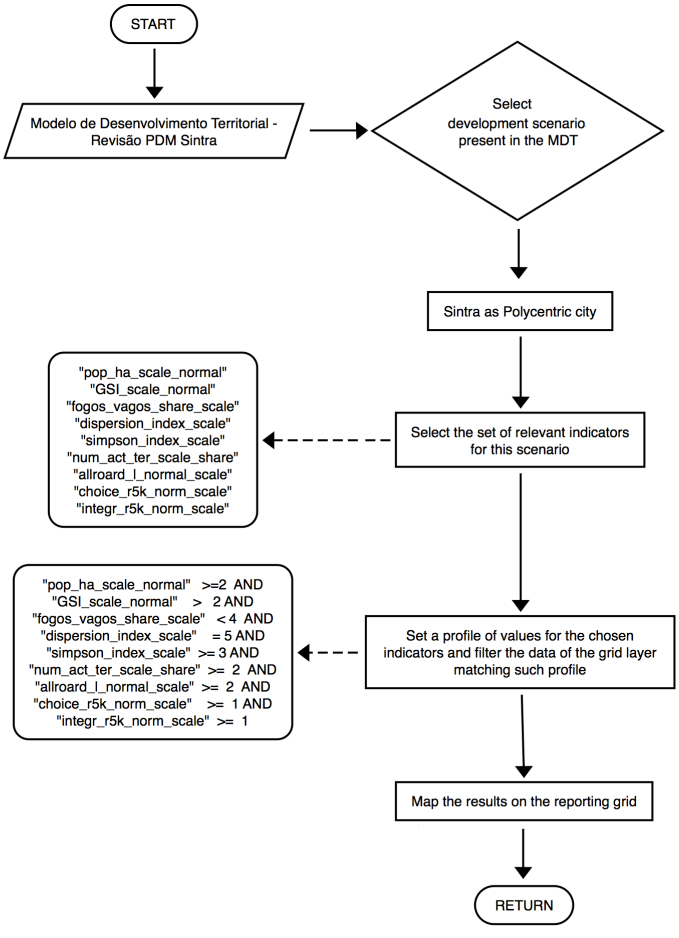

Figure 40 – Territorial profiles calculation workflow

As we already explained in paragraph 4.10, each territorial profile resulted from a specific sequence of values for a specific set of selected indicators calculated on the custom territorial grid 100x100m. In order to select different profiles for the given territory. Here we will look at the methods that led step-by-step to the calculation of the territorial profiles.

5.7.1 Correlation study of territorial indicators

In order to reduce the number of territorial indicators to the ones that proved to be relevant for this study, we decided to perform a correlation study. Correlational study is a type of research method, in which one measures two variables, in order to understand and assess the statistical relationship between them. This tasks was needed here in order to exclude any redundancy between different territorial indictors, excluding the ones that clearly showed a high correlation with others thus being negligible in the final profiling of the territorial units.

Before starting to calculate values of indicators for each territorial profile, we wanted to check if we could narrow down the number of indicators to the essential.

So, in order to narrow down the list of indicators to be used in this study, we decided to perform a correlation study. Correlational study is a type of research method, in which one measures two variables, in order to understand and assess the statistical relationship between them. This tasks allows to exclude any redundancy between different territorial indictors. Such correlation study made possible to decrease the total number of indicators, without loosing any detail in the final analysis. For this task, in the present study we used a statistical software called JMP to perform the correlation analysis of the various territorial indicators narrowing down the list of indicators to the essentials. To do this we performed a Multivariate Analysis correlating all the indicators previously calculated in this work with each other, in order to spot correlations between them.

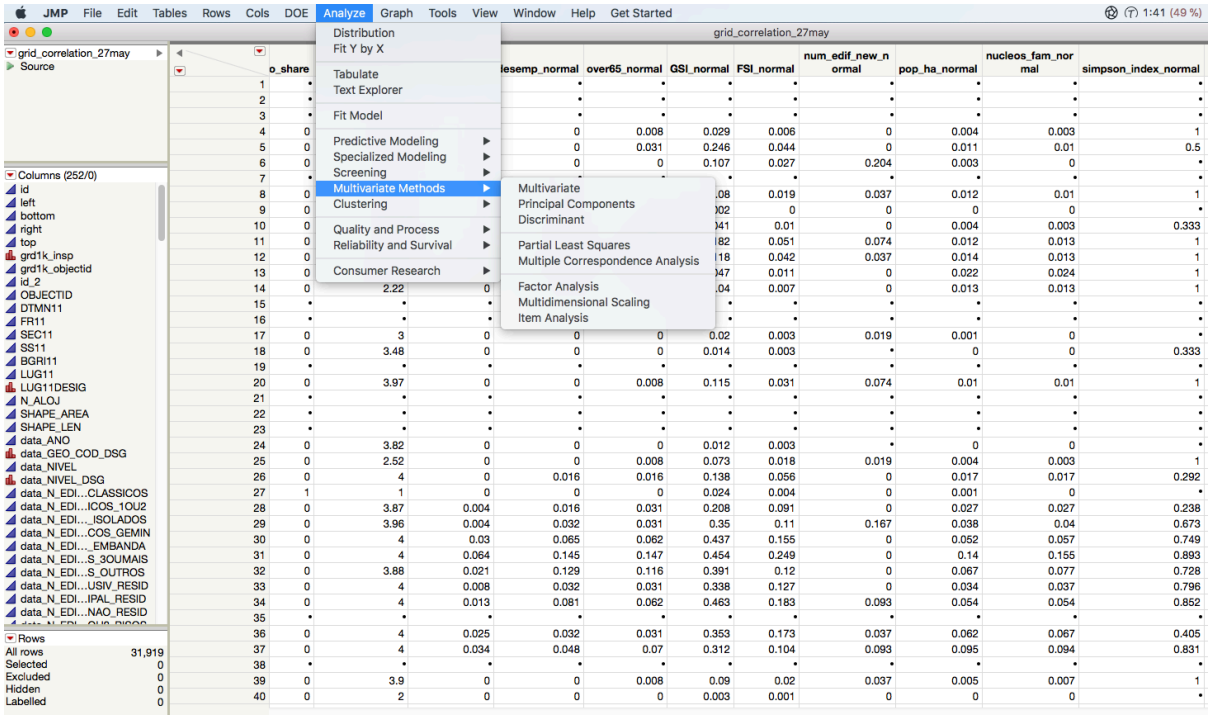

Figure 41 - Screenshot of the correlation study in the JMP environment

In a correlation study, coefficient values can range from +1 to -1, where +1 indicates a perfect positive correlation, -1 indicates a perfect negative correlation (or inverse correlation) and a 0 indicates that no relationship exists between the two variables – in our case between the two territorial indicators.

In statistics, it is defined as positive correlation a relationship between two variables in which both variables move in tandem. A positive correlation exists when one variable decreases as the other variable decreases, or one variable increases while the other increases. An inverse correlation, also known as negative correlation, is a contrary relationship between two variables such that they move in opposite directions. For example, with variables A and B, as A increases, B decreases, and as A decreases, B increases. In the present study we decided to set ±0.8 as a dividing threshold of correlation – to either keep or discard a certain indicator. What fell over the two extremes of ±0.8 value was considered to be too correlated, therefore redundant, for either positive or negative correlation. What fell between -0.8 and +0.8 was considered not strictly correlated so it was kept in the final list of indicators.

JMP software's function Multivariate Analysis while computing such coefficient also helps in visualizing the correlation matrix. Here is an example of the correlation matrix as visualized in the JMP software.

Multivariate

Correlations

	enssup_normal	desemp_normal	over65_normal	GSI_normal	FSI_normal	num_edif_new_normal	pop_ha_normal	nucleos_fam_normal	simpson_index_normal	dispersion_index_normal
enssup_normal	1.0000	0.7130	0.5648	0.4783	0.7025	0.2544	0.8509	0.8561	-0.0519	0.1905
desemp_normal	0.7130	1.0000	0.6372	0.4828	0.7318	0.1127	0.9401	0.9340	-0.0300	0.1936
over65_normal	0.5648	0.6372	1.0000	0.5918	0.6461	0.0588	0.6988	0.7074	-0.0994	0.2341
GSI_normal	0.4783	0.4828	0.5918	1.0000	0.7878	0.3835	0.5521	0.5587	-0.3349	0.4476
FSI_normal	0.7025	0.7318	0.6461	0.7878	1.0000	0.2507	0.8001	0.8025	-0.2127	0.3095
num_edif_new_normal	0.2544	0.1127	0.0588	0.3835	0.2507	1.0000	0.1906	0.1919	-0.1049	0.2405
pop_ha_normal	0.8509	0.9401	0.6988	0.5521	0.8001	0.1906	1.0000	0.9963	-0.0425	0.2247
nucleos_fam_normal	0.8561	0.9340	0.7074	0.5587	0.8025	0.1919	0.9963	1.0000	-0.0446	0.2275
simpson_index_normal	-0.0519	-0.0300	-0.0994	-0.3349	-0.2127	-0.1049	-0.0425	-0.0446	1.0000	-0.2014
dispersion_index_normal	0.1905	0.1936	0.2341	0.4476	0.3095	0.2405	0.2247	0.2275	-0.2014	1.0000
num_activ_tot_normal	0.5231	0.5333	0.5535	0.6508	0.7486	0.1723	0.5832	0.5907	-0.4711	0.2507
num_activ_prim_normal	0.0144	0.0086	0.0256	0.0743	0.0408	0.0264	0.0139	0.0159	-0.1234	0.0304
num_activ_sec_normal	0.3890	0.4083	0.3942	0.4865	0.5594	0.1291	0.4527	0.4586	-0.4387	0.1969
num_activ_ter_normal	0.5173	0.5198	0.5340	0.6165	0.7244	0.1676	0.5673	0.5744	-0.4411	0.2349
connect2_normal	0.1866	0.2130	0.2206	0.3436	0.3144	0.1228	0.2256	0.2289	-0.2029	0.1837
culdesac_normal	0.1313	0.1618	0.1431	0.1319	0.1800	0.0532	0.1605	0.1611	-0.0510	0.0452
sum400intw_normal	0.1489	0.1466	0.1690	0.1204	0.1969	-0.0151	0.1583	0.1664	-0.1229	0.1293
sum1200intw_normal	0.1486	0.1462	0.1695	0.1202	0.1965	-0.0157	0.1579	0.1660	-0.1235	0.1289
sum5kintw_normal	0.1335	0.1360	0.1663	0.1286	0.1856	-0.0058	0.1482	0.1566	-0.1063	0.1254
sum15kintw_normal	0.1335	0.1360	0.1663	0.1286	0.1856	-0.0058	0.1482	0.1566	-0.1063	0.1254
ch400max_normal	-0.0351	-0.0219	-0.0402	-0.0499	-0.0340	-0.0554	-0.0327	-0.0322	-0.0230	0.0030
ch1200max_normal	-0.0353	-0.0224	-0.0405	-0.0516	-0.0349	-0.0558	-0.0333	-0.0328	-0.0234	0.0015
ch5kmax_normal	-0.0213	-0.0121	-0.0154	-0.0163	-0.0087	-0.0380	-0.0202	-0.0188	-0.0428	-0.0028
ch15kmax_normal	-0.0213	-0.0121	-0.0154	-0.0163	-0.0087	-0.0380	-0.0202	-0.0188	-0.0428	-0.0028
allroads_l	0.3231	0.3416	0.3246	0.4774	0.4652	0.2209	0.3704	0.3748	-0.3209	0.2488
allroads_n	0.3225	0.3469	0.3408	0.4637	0.4639	0.1975	0.3716	0.3767	-0.2827	0.2416
allroads_l_normal	0.3231	0.3416	0.3246	0.4774	0.4653	0.2209	0.3704	0.3748	-0.3209	0.2488
allroads_n_normal	0.3225	0.3470	0.3408	0.4636	0.4639	0.1974	0.3716	0.3767	-0.2826	0.2415

Figure 42 - The resulting correlation table

5.7.2 The shortlist of indicators for territorial profiling

After having concluded the correlation study for the original set of indicators, we came out with a shortlist of indicators that, due to the high correlation rates between them and the other ones not included in the shortlist, could be safely taken a sufficient to describe any territorial profile without the need of more indicators.

So, in this way, we selected those indicators that we considered the most appropriate one for the task of calculating different territorial profiles for Sintra's municipal area.

Selected indicators	Type of values
New dwellings 1991-2001	Share
Population per hectar	Normalized
Gross Space Index	Normalized
Empty Dwellings	Share
Dispersion Index	Normalized
Diversity Simpson Index	Normalized
Number of activities of 3rd sector	Share
Choice 5km	Normalized
Integration 5km	Normalized
Infrastructure density	Normalized

Table 3 - Shortlist of indicator for territorial profiling

5.7.3 Re-factoring phase

In order to homogenize the different indicators to a common range of values as well as a common scale, we decided to perform a scaling on each indicator to translate its original values to a scale system from 1 to 5. In fact, feature scaling is a method used to standardize the range of independent variables or features of data.

After having either normalized or transformed in shares the values of each indicator, we thought that a final scaling from 1 to 5 would allow us to compare more easily results coming from different indicators.

In order to determine where to place the breaks between the different ranks 1 to 5, a distribution study has been performed for each indicator. The intervals considered shall be sequences of logical magnitude (each interval has roughly the same size as the previous one). It will depend on the indicator the sequence that is considered most consistent. There will always be a subjective component, which will be minimized with the knowledge of the local reality, and explained whenever it is deemed indispensable to their understanding. Those indicator featuring a high number of values equals to zero or close to zero were treated in a way that the breaks would first isolate most of the results in one break and then it would subdivide the rest of the results in an equally distributed manner.

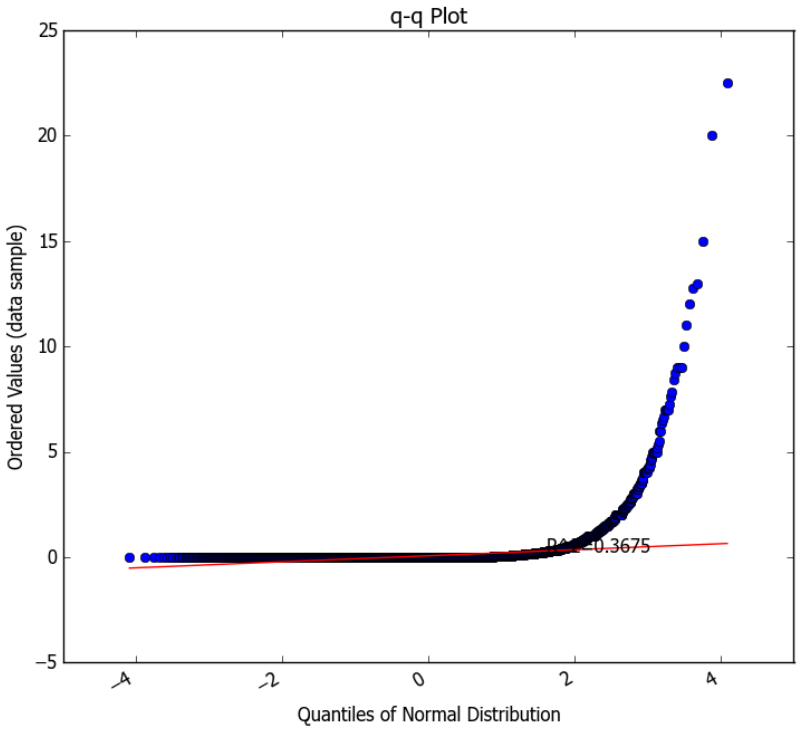

Figure 43 - Distribution study example: the new dwelling 1991-2011 indicator

After having determined how to subdivide the results of the given indicator, we proceed towards the scaling process by creating a new field in the database table that would be fed by the results translated into ranks from 1 to 5 by a SQL query based on the breaks previously defined. Such query is exemplified here with the case of the indicator of the

share of the population over 65 years old by grid cell. This is how the SQL query for scaling the values of the indicator of the share of the population over 65 years old by grid cell looks like:

```
CASE
WHEN "over65_share"  < 0.03407 THEN '1'
WHEN  "over65_share"  >= 0.03407 AND "over65_share"  < 0.13458 THEN '2'
WHEN  "over65_share"  >= 0.13458 AND "over65_share"  < 0.29813 THEN '3'
WHEN  "over65_share"  >= 0.29813 AND "over65_share"  < 0.43782 THEN '4'
WHEN  "over65_share"  >= 0.43782 THEN '5'
ELSE 'none'
END
```

And here is a look at the user interface of the field calculator prompt allowing for the creation of a new field of scaled results for the share of the population over 65 years,

which we called “over65_scale_share”:

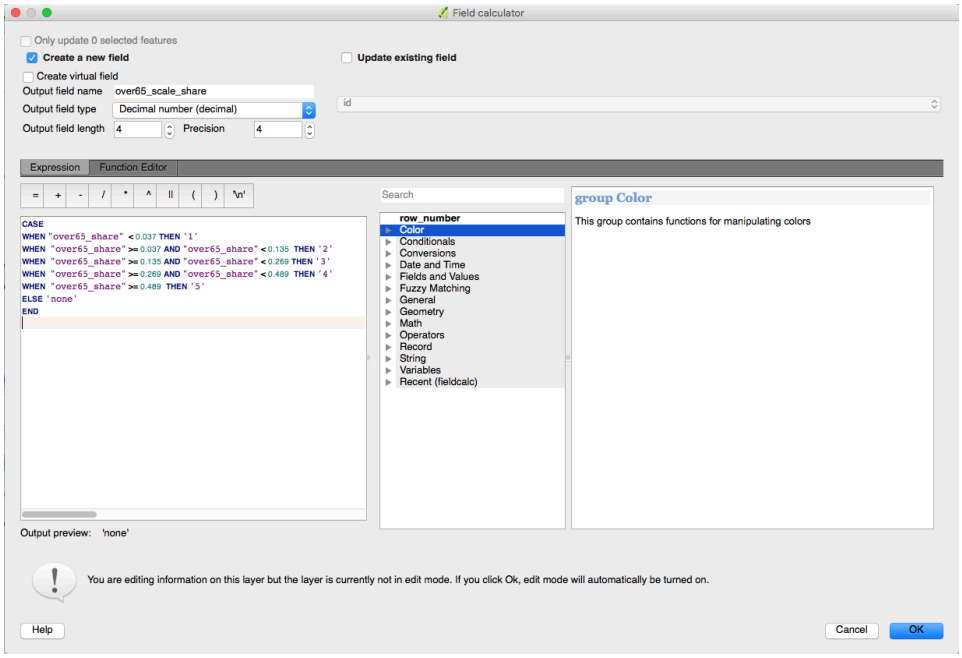

Figure 44 - The refactoring query

5.7.4 The profiling calculation and mapping

For the sake of simplification, we initially thought to group the indicators by their four different dimensions, either by summing them all or by calculating the average. We soon realized nevertheless that this grouping was not the correct way to perform this profiling. In truth, we quickly understood that some values could have a positive influence on the final result while some others could have a negative influence. In other words, some indicators could feature a set of values where the increase in the value would mean a positive effect while some other could work just the opposite – increasing values, negative effect. After this, we started to think to assign to each indicator an either positive or negative sign in the expression but we figured out soon that also this was not the most appropriate method for our aims because one could get a zero sum that would hide the problem related to such calculation.

In fact, the problem here was that some indicators could present preferably a high value for a certain scenario and a low value for another scenario, e.g. one could want the indicator of the share of population over 64 years old to be low when looking at where to locate schools and universities, but could want just the opposite when looking where to locate health services such as hospitals and daycare centers. So, we changed strategy and continued to use the whole set of indicators, instead of grouping them per dimension. In this way, we came to conceive the method of the territorial profiling and its calculation.

Each development scenario is made of a number of profiles chosen by the author. To give an example, we identified a profile called *Centro Urbano Vivo* (Living urban center) –part of the polycentric territory scenario of the municipality of Sintra. Such profile corresponds to a sequence of scores of selected indicators, as shown in the following filter expression:

"num_edif_new_scale_share" >= 1 AND

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" >= 3 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" >= 5 AND

"simpson_index_scale" >= 4 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 2 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 2

Each one of these conditions must be met in order to have the specific grid cell considered as part of the territorial profile. So, such profiling framework acts as a filtering criteria to determine whether or not a certain grid cell is Such filtering would allow us to visualize directly on the map the locations within Sintra's territory that meet the criteria for the given profile.

Each profile can be either described as filtering expression in Qgis or as radar chart for a more intuitive comprehension. A radar chart is a visualization method of displaying multivariate data in the form of a two-dimensional chart of an arbitrary number of quantitative variables represented on axes starting from a center point. Radar charts are primarily suited for strikingly showing outliers and commonalities, which is the case here for the comparison between different territorial profiles.

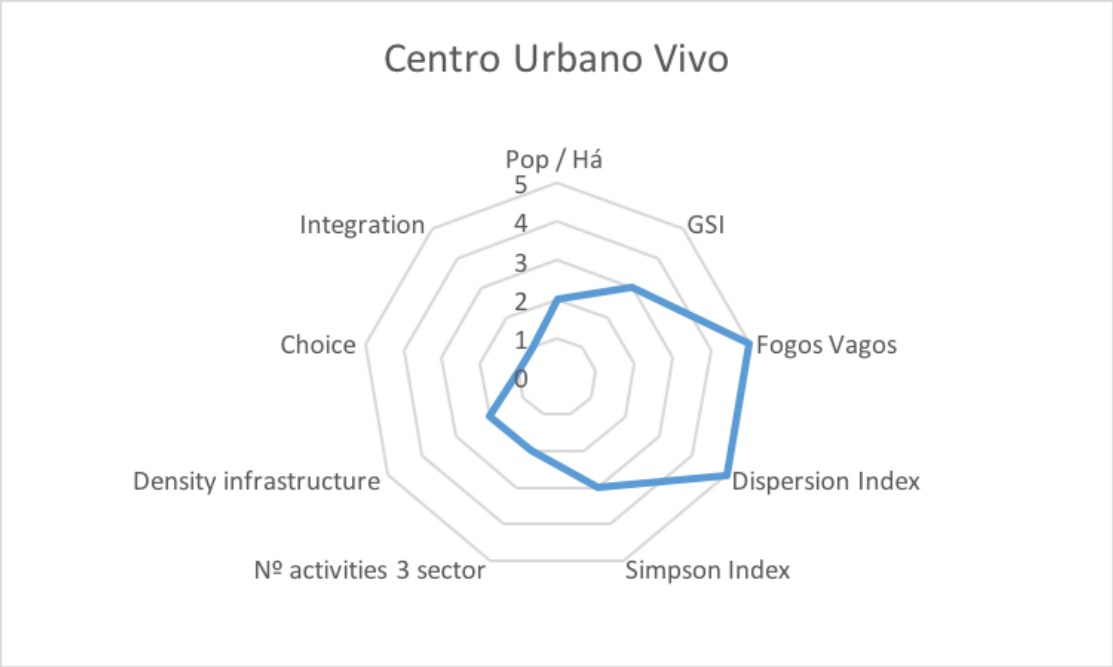

Figure 45 - Example of a radar chart for a territorial profile

After having determined the filtering expression for each territorial profile, the next step is mapping the results of such filtering expression onto the reporting 100x100m grid of Sintra's territory.

PART 3 – APPLICATION AND RESULTS

6. SWOT ANALYSIS SPATIALIZATION

After having seen the step-by-step procedure that enables to get to the spatialization of the SWOT analysis, we will present here the application of such spatialization.

Clearly, there will always be items of a SWOT analysis that cannot be translated into any spatial representation nor can be considered to have any specific spatial dimension. For many other items, though, it is possible to calculate and visualize their spatial dimension.

This is what we intend to do with the spatialization of the SWOT analysis for Sintra's territory.

Here we present the items of the SWOT analysis performed by the Gabinete do Plano Diretor Municipal de Sintra that proved to have a spatial dimension and therefore could be amenable to a spatial representation.

To do that we will first present, by every dimension of the SWOT analysis (strengths, weaknesses, opportunities and threats), a table that will help discern between the items that do have a spatial dimension – and therefore are amenable to a spatial representation – and the one that don't have any spatial dimension. Moreover, we will indicate for which item we had access to the data needed to perform such spatialization and for which we didn't.

As we explained in the methodology, the process of giving a spatial representation to the items of the SWOT analysis is central to the understanding of the spatial processes that characterize the municipal area.

The advantages of achieving a spatialized representation of the items of the SWOT analysis using the data available on the territory are manifolds:

- Firstly, the spatialization enables an immediate feedback
- The choice of working on a custom reporting grid, meant that we immediately got able to compare and cross-reference data from different realms and make connections between different items of the SWOT analysis, efficiently integrating the more generic strategic overlook given by the classic SWOT analysis.

We now will proceed by looking at each specific item of the SWOT analysis.

6.1 Strenghts

Item name and dimension in Sintra's PDM	Short name
EXCEPTIONAL HERITAGE	
Significant number of classified monuments and archaeological sites scattered throughout the municipal area (heritage dispersion as a factor of balance and attractiveness of various sites).	Classified monuments
NATURAL RESOURCES AND ENVIRONMENTAL QUALITY	
Existence of natural resources of geological and biogeographic value (soil, subsoil and biophysical) and environmental quality (air, water and soil).	Geological Resources
High percentage of the municipality occupied by agricultural, agroforestry and forest areas, with potential for growth, and differentiating elements.	Vegetation resources
POPULATION / HUMAN CAPITAL	
Second most populous municipality in the country, with a multicultural, diverse, and young population, increasingly educated and qualified.	Human capital
SIGNIFICANT ENTRERPRENEURSHIP VALUE AND BUSINESS DYNAMICS	
Second municipality of the Greater Lisbon with the largest number of companies, and with a higher activity rate than AML and the country.	Entrepreneurial capital
GROWING VALORIZATION OF IDENTITY, CULTURE AND PRODUCTS FROM THE TERRITORY	
Existence of cultural and creative industries, with a strong cultural component.	Cultural industry
COLLECTIVE USE AND SOCIAL SUPPORT EQUIPMENT	
Increased supply of public equipment in quantity and quality (kindergartens, schools, culture, leisure and sports).	Public Equipments

Table 4 - List of "Strengths" from the SWOT analysis that have a spatial expression

From this list we extracted the items that could be represented in a spatial manner and for which we had sufficient data to perform such spatialization. For each of those that met those two criteria we performed a spatial query using the the grid system proposed for the entire work and we visualized the results on such reporting grid system.

Here are the detailed mappings for each SWOT analysis item that we were able to translate into a spatial representation.

6.1.1 Exceptional heritage

In order to represent the relevance of the cultural heritage throughout the municipality of Sintra, we mapped the portions of Sintra's territory by density of monuments count – a layer of information that the municipality made available for us.

6.1.1.1 Classified monuments

We started by mapping each location in the 100x100m grid of Sintra's territory by density of monuments and archeological sites. What is interesting to see is that, contrary to what is commonly believed, Sintra offers a wide array to cultural sites throughout its whole municipal territory. The territorial dispersion of such cultural landscape plays as a leveling factor contributing for a distributed attractiveness to different parts of Sintra's municipal area.

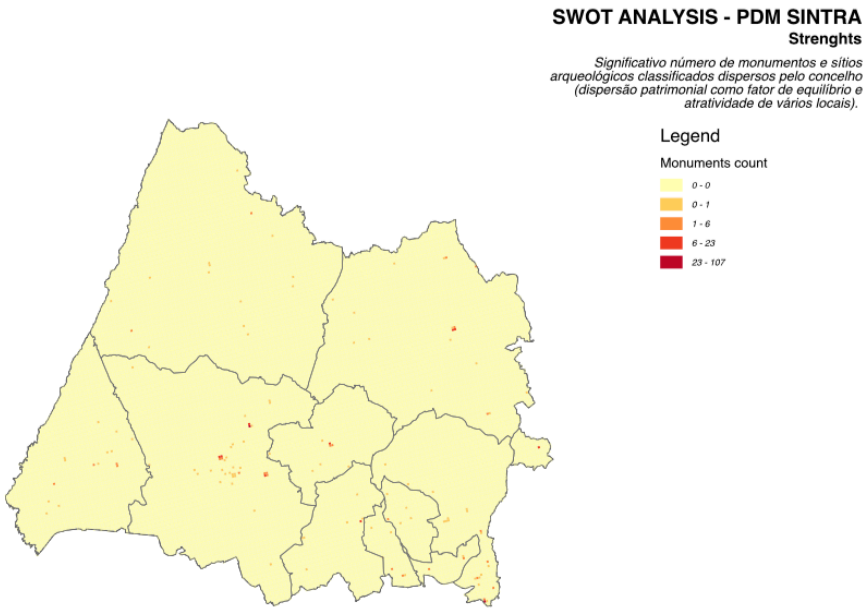

Figure 46 – Mapping of the classified monuments

In fact, beside the Unesco's World Heritage Site of Sintra's historical town and hilltop palaces, the municipal territory hosts a great number of historical buldings and archeological sites, all classified and of great historical value. This has been pointed out as a major strength for Sintra.

6.1.2 Natural resources and enviromental quality

Sintra's municipal territory encompasses areas of great sensitivity for its floristic and landscape value, as well as for it geomorphologic characteristics.

In order to represent the presence of natural resources and environmental quality throughout the municipal territory of Sintra, however we had to work with the scarce data made available by the municipality. The only layer of information that the municipality made available for us in this case has been the location of quarries. To that we added the land cover as provided by the Copernicus project database. Copernicus is a European Union project that aims at monitoring the Earth. Data is collected by different sources, including Earth observation satellites and in-situ sensors. Among several other outcomes, Copernicus provide a detailed land-cover mapping for the whole European Union.

The municipality of Sintra however provided us with no other information regarding soil and subsoil type or the environmental quality of air, waters and soils. Such information could be however be integrated in the model in the future, adding more levels of analysis and understanding to whole model.

So, in the absence of such data, we started by mapping the locations in the 100x100m grid of Sintra's territory that featured the presence of quarries and extractive sites.

6.1.2.1 Geological resources

What is possible to deduct from such mapping is that due to the fact that quarries are activities that usually occupy a rather large area, the study of the density of such activity on a 100x100m reporting grid doesn't render the density of such quarries but rather their presence or absence in each grid cell.

Clearly the majority of the cells invested by quarries are located in the area comprised between the centers of Pero Pinheiro and Montelavar, in the north-east part of the municipality, which is renowed for its stone extraction and transformation activity.

While this is a layer of information purely dealing with environmental features and land cover, it is interesting from the point of view of our future analysis to establish a link between the location of such extractive site and the transportation network: this in order to assess the accessibility of such extractive sites and stone-cutting industrial activities from the road network.

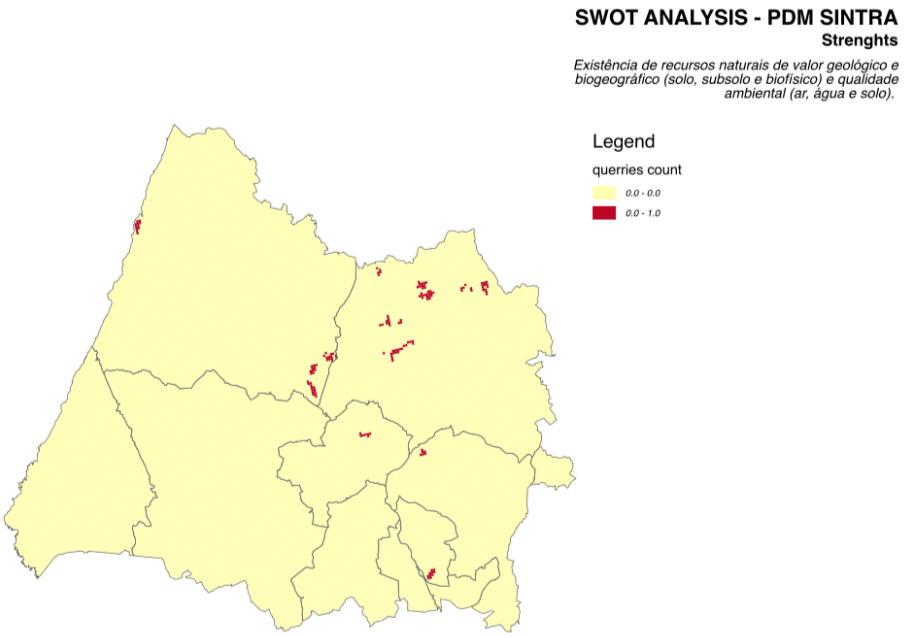

Figure 47 – Mapping of the geological resources

6.1.2.2 Vegetation resources

The mapping "High percentage of municipal territory occupied by agricultural, agroforest, and forest areas, with potential of growing and with differentiating elements" shows how Sintra's territory is characterized by a high degree of diversity of its land cover featuring a high percentage of areas covered by agriculture, agroforests and forests. By mapping the different kinds of natural surfaces land cover, divided by category, and reported on the custom grid 100x100m, it is possible to appreciate the diversity of the land cover and its more general repartition. From this representation is possible to note that the distribution of the forests is mostly concentrated in the mountain area in the Serra de Sintra but also along the Atlantic shore and more scattered in some mountain areas in the East of the municipality. The Serra de Sintra comprises a wide agricultural area to the north of Colares that includes the plain of Sâo João das Lampas, the other is the shoreline between the mouth of the Falcão river and the city of Cascais, ending to the West at the Cape of Roca, where herbaceous vegetation abounds. Herbaceous vegetation is also present in the East part of the municipal area.

The arable lands tend to occupy those zones around the plain of Sâo João das Lampas in the west part of the municipality while the pastures are mostly concentrated in the North part of the municipality.

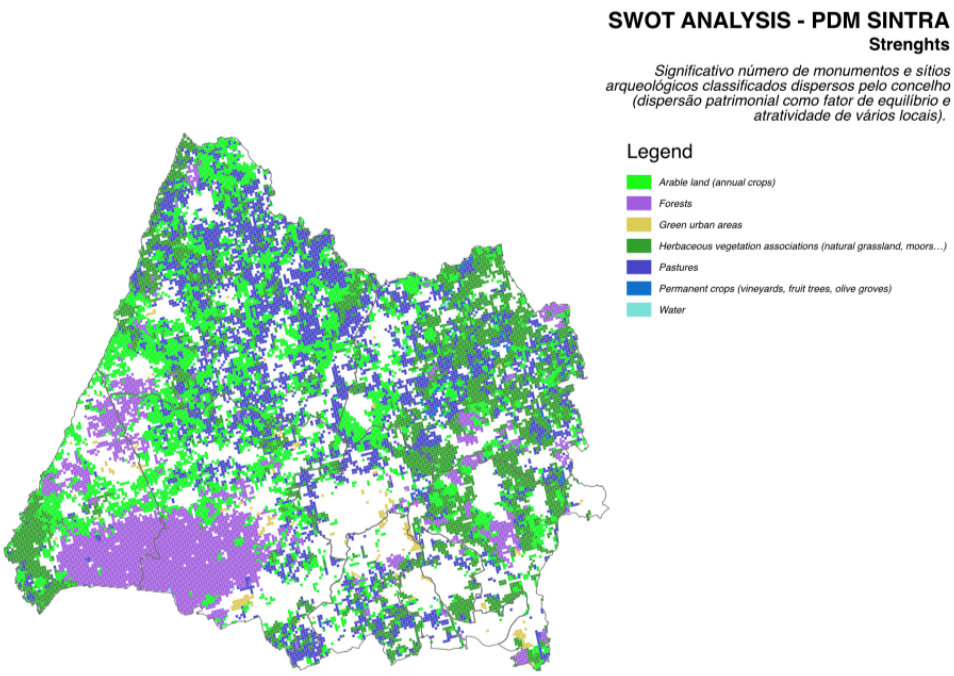

Figure 48 - Mapping of the vegetation resources

6.1.3 Population and human capital

Featuring a population of 377.000 inhabitants Sintra is, in fact, just after Lisbon (547 .000 inhabitants) the second most populous municipality in Portugal.

The Municipality of Sintra in the period 2001-2011 showed a marked increase of population (plus 3.73%), compared to the national average (plus 1.95%). However, this relative variation is attenuated in the metropolitan context of Lisbon, which registered a growth rate of 5.67%. Urban consolidation and / or depletion of the urban space, coupled with the aging of the housing stock and the resident population, appear to be a relevant factor in this demographic balance, more restrained than in previous decades.

6.1.3.1 Human capital

In order to represent on the proposed territorial grid the strengths of Sintra's population features, we made several mapping capturing its multicultural, diversified, young and increasingly educated population.

The first mapping represents the population density per hectar. Here it is clearly visible how Sintra's urbanization has been influenced and mostly bounded by the railway axis Lisbon-Sintra, upon which the urban axis of modern Sintra developed. In the mapping such conglomeration constitutes the axis of the most densely populated areas of the municipality while it is also visible the widespread urban dispersion that characterizes Sintra's peripheral areas.

The large landscape diversity of the Sintra Municipality, with a strong urban component and extensive rural and forest area, nevertheless prefigures a densely populated territory (1184 inhabitants / km2) even on the scale of the AML (973 hab./Km2) and above all in the national level (115 hab./Km2). However, it departs considerably from the density values of large population concentrations such as Amadora (7365 hab./Km2), Lisbon (6461 hab./km2) and Odivelas (5486Hb./km2), among other neighboring municipalities, except for Mafra.

The *freguesias* inserted in the urban corridor, with the inherent high land value, and accesses to the train and the main road axis, concentrate of density ten to twelve times higher than the average of the municipality. Monte Abraão, Massamá and Queluz exceed 10 000 inhabitants per km2.

On the other hand, the coastal and northern areas of the municipality, with a predominance of single-family buildings, are below 400 inhab./km2, with the minimum densities to be registered in the parish of São João das Lampas 199 hab / Km2, Terrugem (219) and Colares (231).

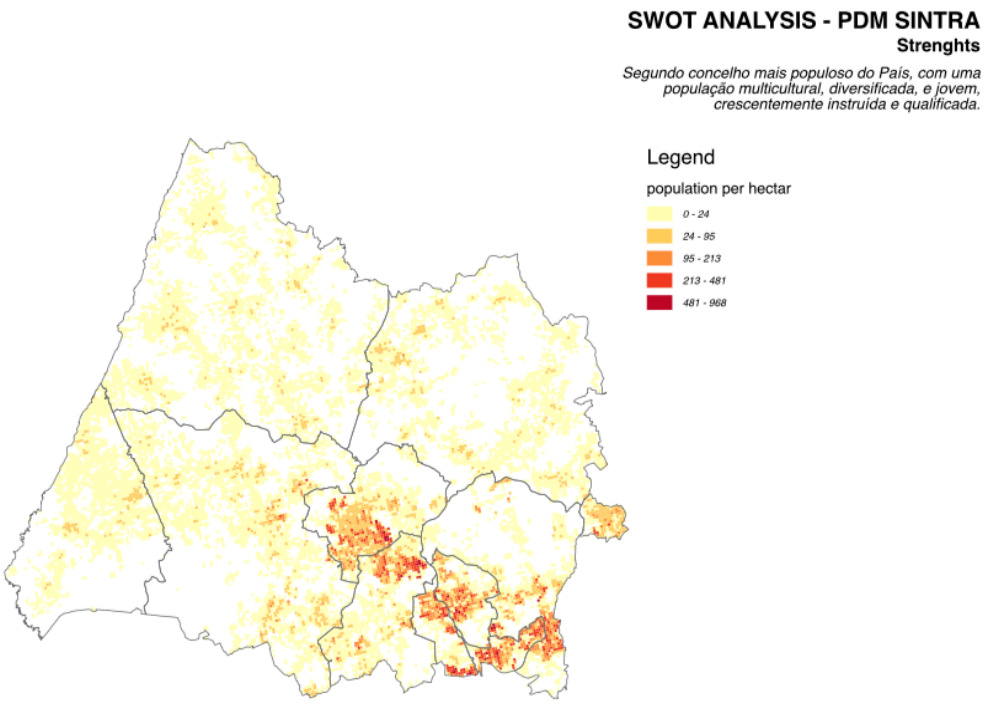

Figure 49 - Mapping of the population density

Another important trait of Sintra's population is the relative young age of its residents.

Regarding the age of its population, the Municipality of Sintra presents the most balanced pyramid of the regional context, in other words, in addition to surpassing the national and regional mean values, it generates conditions that are potentially very favorable to the maintenance of positive natural growth and balance of the population. This will allow the potential natural regeneration of the population, while safeguarding the impact of migratory flows, which are always fluctuating and highly conditioned by the economic and employment context.

In Sintra, the 0-19 age group makes up 29.5% of the population (the highest value of the North AML), while the lowest percentage in the same territorial context corresponds to the age group above 65 years -13.7%.

On the opposite side is the Municipality of Lisbon, which gathers the most unbalanced age pyramid of Greater Lisbon (AML Norte), with the population above 65 years of age, which already surpasses that of the 0-19 age group. In the distribution of the population of the 0-4 years by statistical section, there is a high correspondence between the most recent urban operations (located in the periphery of the urban axis) and the greater frequency of individuals in this age group. The spatial distribution of the age group up to the age of 13, still in the phase of use of school equipment, does not present significant deviation to the above pattern, that is to say in the immediate periphery of the urban corridor, mainly corresponding to the recent urban operations.

On the other hand, the predominance of population aged 65 and over has a more dispersed distribution in the territory of the municipality and is concentrated in two distinct types of territory: the oldest urbanized nuclei (Mira-Sintra, Algueirão-Mem-Martins, Queluz and Vila de Sintra) and in rural areas (Almargem do Bispo, Montelavar and São João das Lampas).

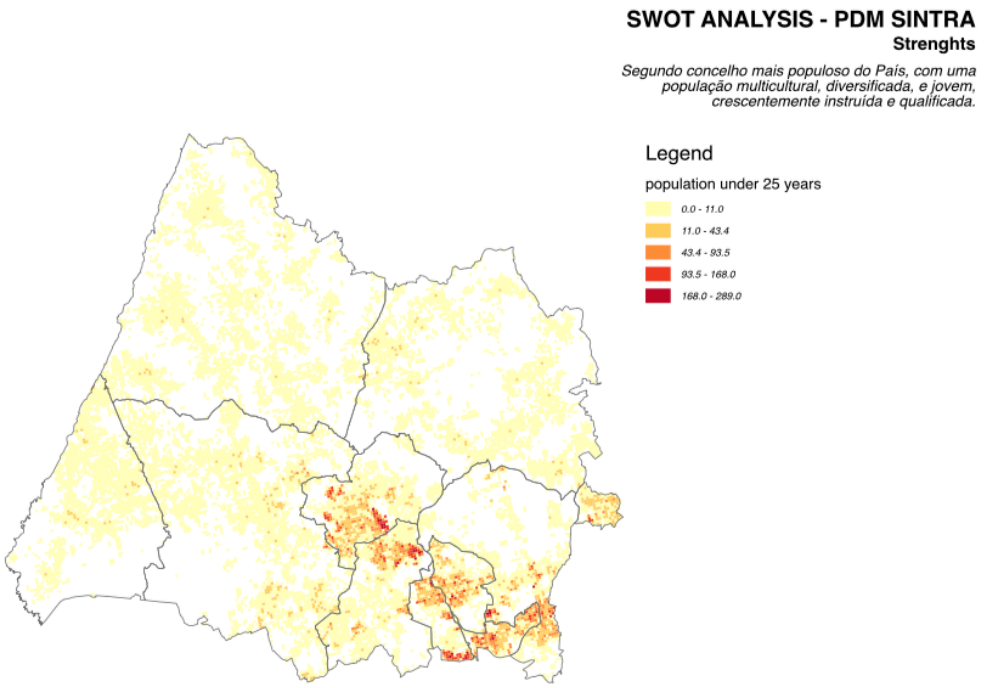

Figure 50 - Mapping of the distribution of the population under 25 years old

In Figure 50, it is possible to see how the concentration of residents under 25 years old in unevenly distributed. While the most populated areas sport a high degree of residents under 25 years old, the most peripheric areas show very low values of residents under 25 years old.

Regarding the level of education of its population, Sintra features a percentage of residents with a level of education corresponding to ISCED classes 5 to 8 also unevenly distributed throughout its territory. Here the maps shows how the more peripheric areas in the municipality are less likely to be inhabited by people with higher education levels.

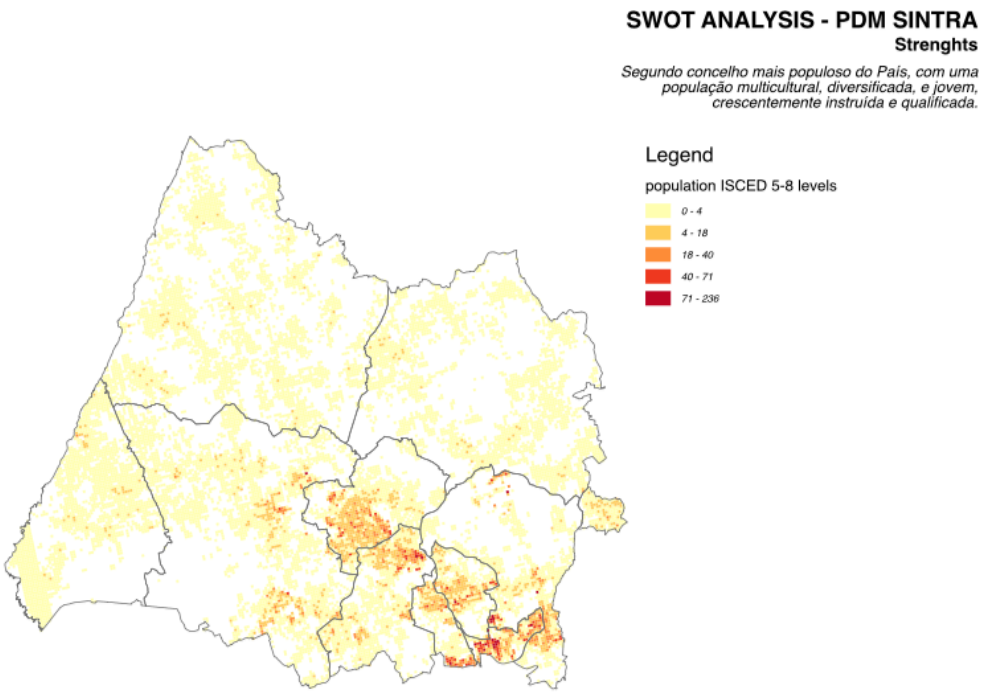

Figure 51 - Mapping of the distribution of population with ISCED education levels 5-8

6.1.4 Entrepreneurial capital

The municipality of Sintra plays an important part in Lisbon Metropolitan Area's economy, which represents about 37% of national GDP and concentrates a significant number of technological and research companies. In 2012, 34316 companies were based in the municipality, about 11.1% of the total of the AML, 96.4% of them are small companies employing an average of 3.1 workers per company.

Currently, the municipal economic structure is dominated by the tertiary sector (84.4%), followed by the secondary (14.5%) and primary (1, 1%). The main factors that supported the establishment of companies in the last two decades in the municipal area of Sintra were the improvement of accessibility, the creation of new locations for companies that wanted to relocate, the existence of young human resources - especially thanks to migratory flow – availability of land and land prices, and finally proximity to major markets, particularly Lisbon.

Second municipality of the Greater Lisbon with the largest number of companies, and with a higher activity rate than AML and the country.

As highlighted by the map below, Sintra's territory features areas of extremely high density of businesses, again concentrated along the urban corridor of the railway axis Lisbon-Sintra. Also it is possible to see how companies in search of new locations and attracted by relatively low land prices started to spread out from the urban corridor outwards creating new centralities of production and work. In the rural areas in the

north of the municipal territory, in places like Montelavar, Terrugem, Casal de Cambra scattered relative concentrations also abounds.

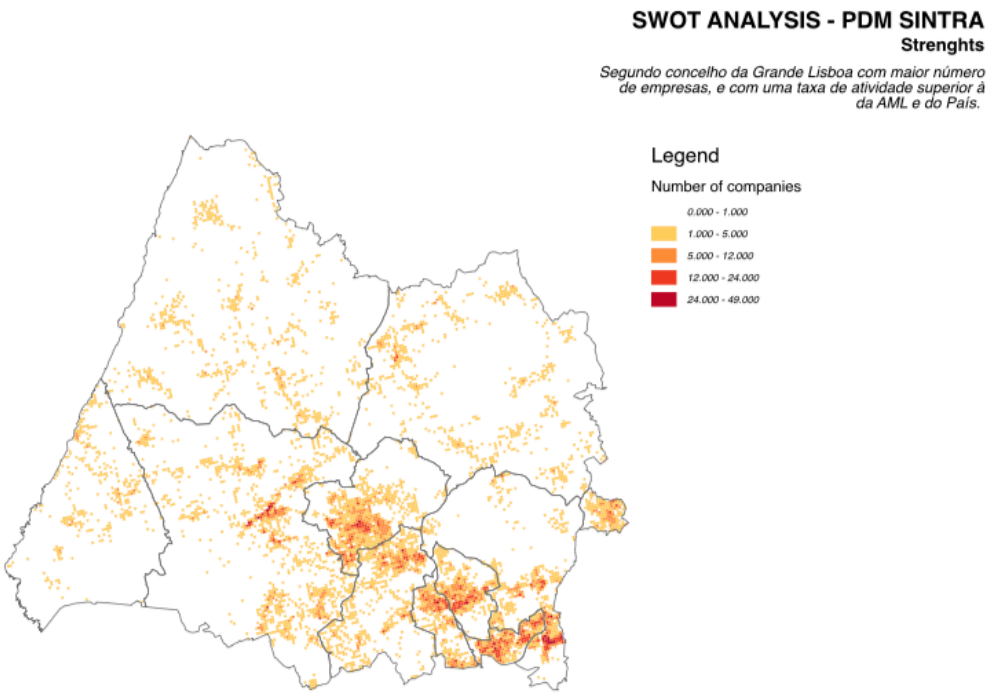

Figure 52 - Mapping of the density of companies

6.1.5 Increasing recognition of local identity and culture

6.1.5.1 Cultural industry

Sintra's image as a brand is strongly associated with its cultural identity. Over the decades Sintra's brand build itself a name for cultural and creative activities. In fact, Sintra's economic fabric features a high degree of businesses from creative industries, with a high cultural impact.

In order to map the location of both cultural and creative industries of Sintra and therefore to spatialize the relevance of such sector over Sintra's territory, we performed count per grid cell of a specific set of economic activities filtered by attribute. The filter applied highlights the locations of those geo-located economic activities falling into the categories of cultural or creative industries.

Part of this culture-related industry are businesses related to leisure and culture, arts and crafts, while businesses related to communication and marketing, IT, media and sports are part of the so-called creative industry. Here below, the filtering expression used in the SQL code in order to highlight the activities falling in those categories.

"type" = 'Arte e Artesanato'
OR "type" = 'Artes Gráficas'
OR "type" = 'Audiovisuais'
OR "type" = 'Cultura e Lazer'
OR "type" = 'Ensino'
OR "type" = 'Informática'
OR"type" = 'Media'
OR "type" = 'Publicidade e Marketing'
OR "type" = 'lazer-cultura-desporto'

OR"type" = 'marketing-comunicacao'

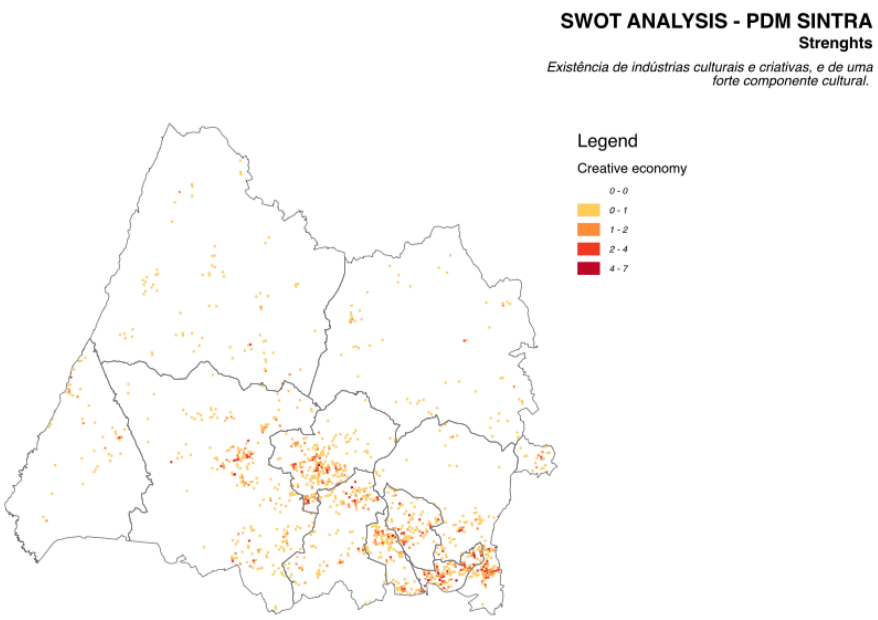

Figure 53 - Mapping of the distribution of cultural and creative activities

The mapping of the distribution of the cultural and creative activities of the municipal area shows a similar dynamic as the one of the overall distribution of companies throughout the municipal area but with a more intense concentration along the urban axis of Mira-Sintra, Algueirão-Mem-Martins, Queluz and Vila de Sintra.

6.1.6 Public services and social support

6.1.6.1 Public equipments

In a similar manner as for the spatialization of Sintra's cultural and creative industry, we mapped the locations of those services such as kindergartens, schools, culture, leisure and sports activities, allowing us to analyse the distribution of such services over Sintra's municipal area.

Here also we performed a count per grid cell of a specific set of activities filtered by attribute.

Below the filtering expression used in the SQL code in order to highlight the activities falling in those categories.

"type" = 'Cultura e Lazer'

OR "type" = 'Ensino'

OR "type" = 'lazer-cultura-desporto'

OR "type" = 'Desporto'

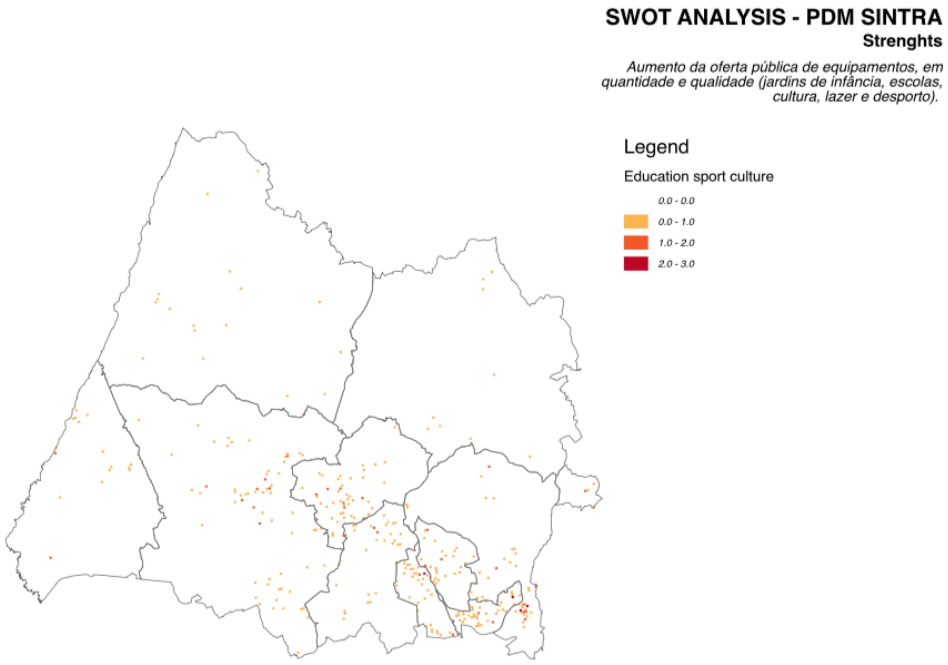

Figure 54 - Mapping of sports, education and cultural equipments (activities)

Interestingly enough the mapping of the distribution of such public services shows less intense concentration along the urban axis of Mira-Sintra, Algueirão-Mem-Martins, Queluz and Vila de Sintra as compared with the spatial distribution of the businesses related to leisure and culture.

6.2 Weaknesses

WEAKNESSES	**Short name**
DEGRADATION OF THE LANDSCAPE, ENVIRONMENT AND HERITAGE	
Urban sprawl (especially in the countryside).	Urban sprawl

EMPLOYMENT AND QUALIFICATION	
Poorly qualified and progressively aging population (increasing aging rate and decreasing birth rate).	Aging and poorly qualified population
High unemployment rate (higher than AML and Country).	Unemployed population
POTENTIAL DEPLETION OF NATURAL RESOURCES	
Prevalence of suburban characteristics in areas with a strong housing component and reduced supply of local businesses and services to make them more sustainable (monofunctionality)	Suburban characteristics
Underutilization of housing stock (high number of vacant dwellings) at the same time as there is a shortage in the supply of social housing.	Empty dwellings
Poor connectivity between urban centralities	Poor connectivity

Table 5 - List of "Weaknesses" from the SWOT analysis that have a spatial expression

6.2.1 Degradation of the landscape, environment and heritage

As in many territories in Portugal the issue of land consumption has been a serious thread to the integrity of the landscape. High rates of soil consumption associated with unregulated urban sprawl translated into a degradation of the environmental value of such territories as well as of the landscape and heritage attractiveness.

The present works departs from the issue of how to mitigate the effects of such sprawl and how to regulate the future development of such dispersed territories in a way that they can gain more coherence and competitiveness both from a geo-strategic point of view and from an economic point of view.

6.2.1.1 Urban sprawl

The analysis of the land occupation in the municipal area of Sintra shows a high rate of urban sprawl. In fact, beside the historical settlements of Queluz and Vila de Sintra and the oldest urbanized nuclei (Mira-Sintra and Algueirão-Mem-Martins) the rest of the territory is affected by several phenomena of severe urban dispersion as it happens in many formerly purely rural areas (Almargem do Bispo, Montelavar and São João das Lampas).

The mapping in Figure 55 shows a representation of the dispersion index normalized. The more intense the color the higher the value of dispersion index. It is interesting to see how almost the whole rural areas present scattered points of high values of dispersion index.

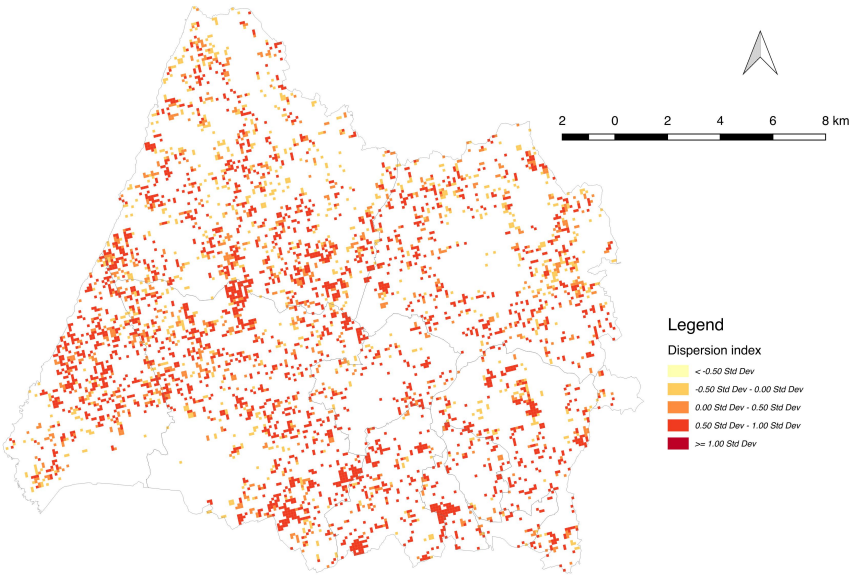

Figure 55 - Mapping of urban dispersion

6.2.2 Employment and qualification

Employment rates and overall qualification of the population are key elements for building a strong "human capital" that can translates into potential for territorial development and competitiveness.

6.2.2.1 Aging and poorly qualified population

Aging population and poorly qualified population are two of the biggest threats to territorial development and economic growth. In fact, Sintra's stands out in the whole AML North as one of the regions with lowest education levels but historically also one with the lowest values of aging index. As the aging index is increasing there are concerns about the future development of the territory. Figure 56 shows the relation between these two variables.

Apart from the urban axis, there a few locations that display a high value in population with higher education (ISCED 5-8), for example in the area of Belas and Beloura, polarized around the golf club and somewhere more scattered between Vila de Sintra and the coast. Interestingly also there are some high values around Casal de Cambra, showing a regeneration of the social context previously more problematic than now. As for the agin index, while we can see lower values along the urban axis, we find peaks of high values scattered among the dispersed areas of Casal da Granja, the Vila de Sintra area, Belas area and to a lesser extent some areas around Montelavar.

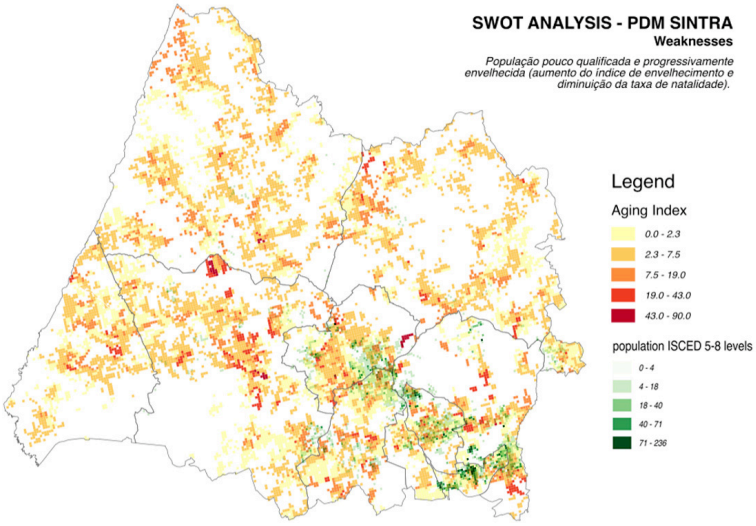

Figure 56 - Mapping of aging and poorly qualified population

6.2.2.2 Unemployed population

By looking at the unemployment map, the interesting fact that is pretty evident from the first look is that the more rural areas are less affected by this phenomenon while the peripheries of the centers on the urban axis are the ones that seem to be more affected.

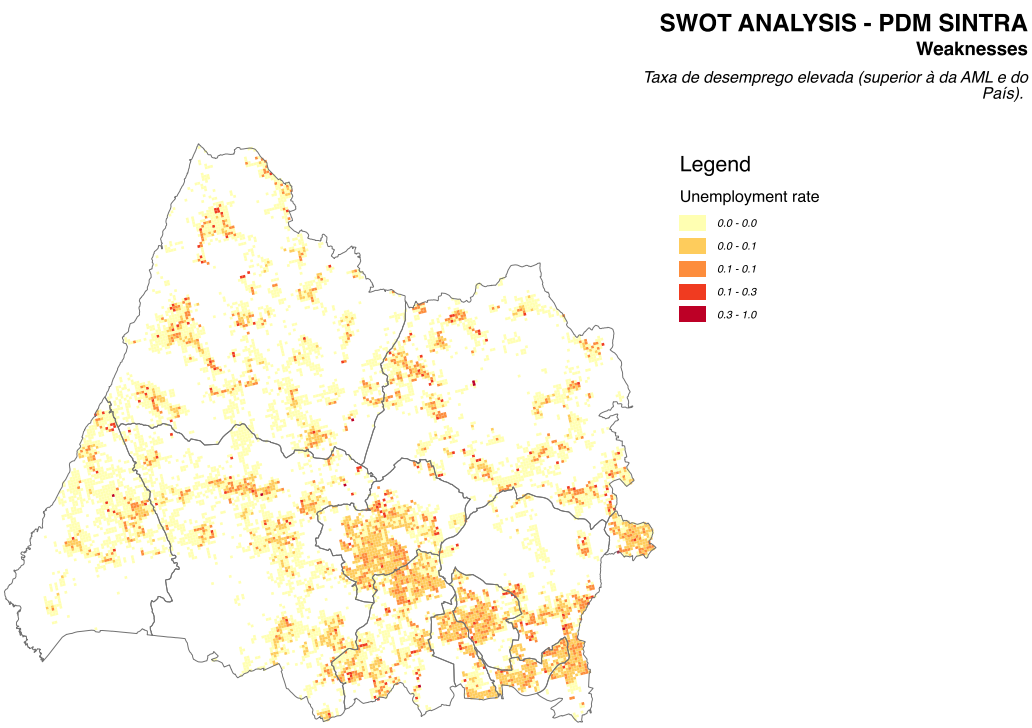

Figure 57 - Mapping of the distribution of unemployment

6.2.3 Potential depletion of natural resources

As we saw any strong approach to sustainable development considers natural resources as a not fungible asset, meaning that they it cannot be replaced by any man-made asset.

6.2.3.1 Suburban characteristics

In order to look at those location where suburban characteristics of monofunctionality were more present, we performed a Simpson Index analysis. Such analysis returned the degree to diversity between different functions: residential funcaion, economic activities of the first sector, of the second sector and finally of the third sector.

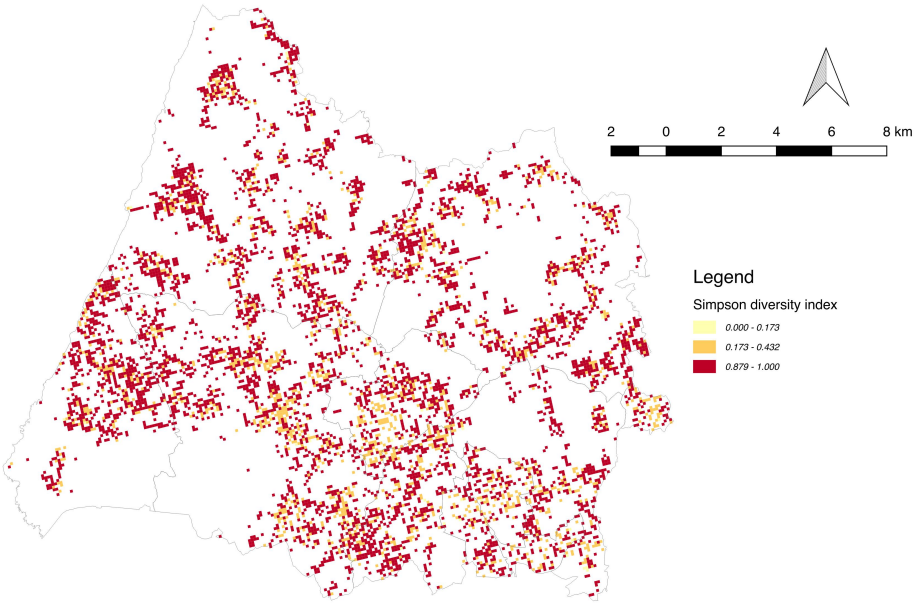

Figure 58 - Mapping of the Diversity Simpson's Index (3 highest ranked classes)

6.2.3.2 Empty dwellings

The overall distribution of the locations where the share of empty dwellings over the total shows the highest values is represented in Figure 59.

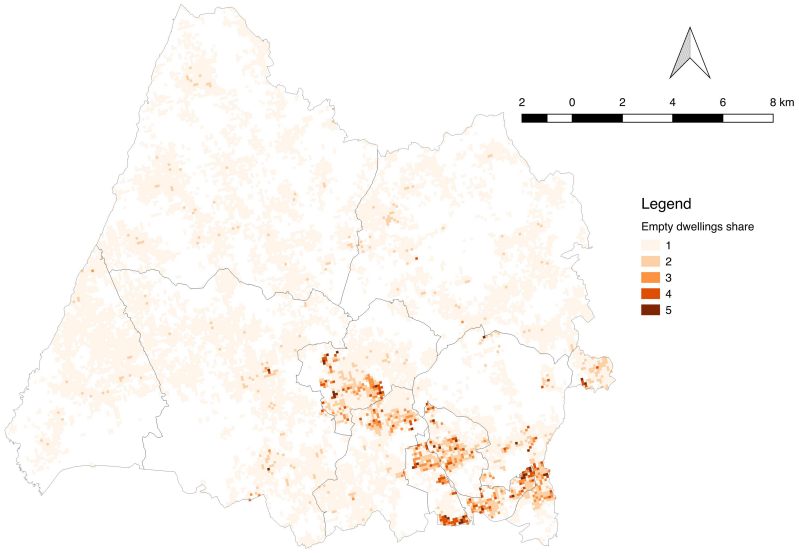

Figure 59 - Empty dwellings map

Looking at their distribution one can easily see how the locations whose share of empty dwellings over the total number of dwelling are clearly concentrated along the urban axis, with a few peaks in São Marcos, Monte Abrão, Queluz and Mem Martins.

6.2.3.3 Poor connectivity

The poor connectivity between urban centers has been pointed as a weakness of the territorial system of Sintra particularly considering that Sintra has the goal of creating a polycentric territory with better quality of life for near future. In fact, a connectivity between centers can be seen while looking at the map in Figure 60 that highlights the road segments with higher Choice value. These segments are to be found mostly in the high-speed roads that connect Sintra with Lisbon. Essentially no direct connection between the different urban centers of Sintra stands out in term of connectivity.

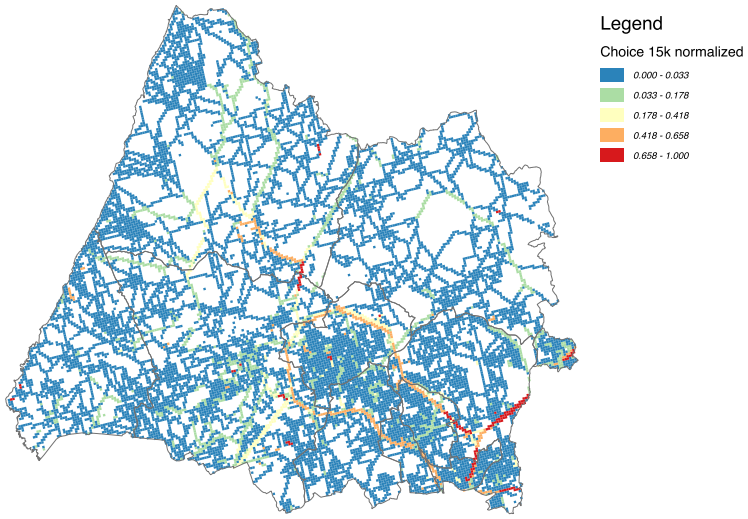

Figure 60 - Mapping of the value of Choice 15km normalized.

6.3 Opportunities

OPPORTUNITIES	**Short name**	**Spatial Expression**
FAVORABLE CONTEXT FOR INCREASING COMPETITIVITY AND DEVELOPMENT		
Integration in the AML / proximity to the capital / proximity to Tagus Park (set of competitive advantages).	Integration in the AML	Yes

Table 6 - List of "Opportunities" from the SWOT analysis that have a spatial expression

6.3.1 Favorable context for increasing competitivity and development

As the only item of the SWOT analysis section Opportunities that had a spatial expression and therefore is amenable to be spatialized here, we present here the Integration in the AML item.

6.3.1.1 Integration in the AML

Sintra with its good integration in the AML and its proximity to the capital as well as to the Tagus Park, is well located and capable of capitalizing from this privileged location.

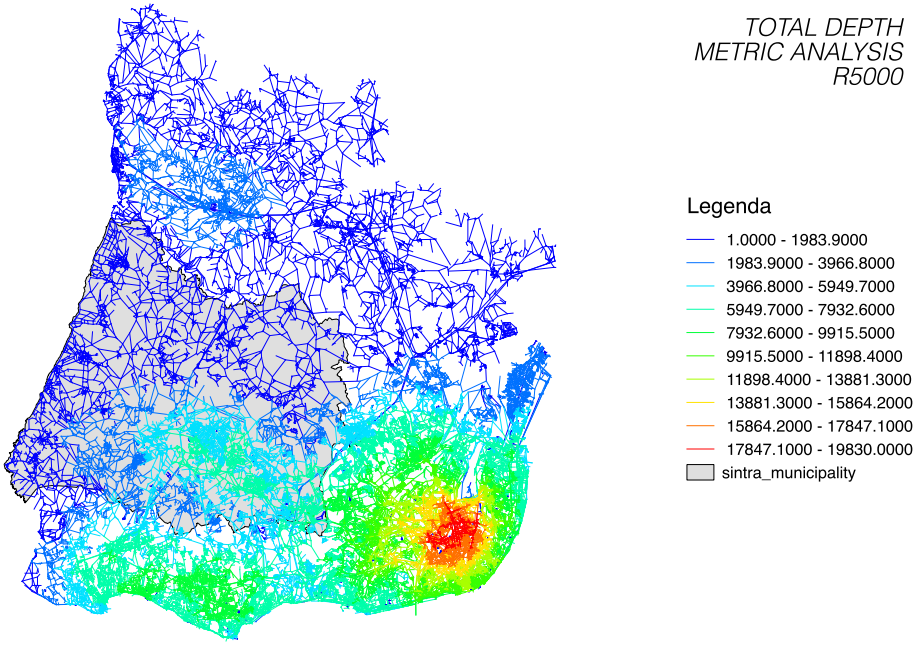

Figure 61 – Map showing the integration of Sintra in the AML North

6.4 Threats

THREATS	**Short namme**	**Spatial expression**
URBAN PRESSURE		
Urban pressure in areas that still preserve natural features (coastal zone, nature park, environmental and landscape sensitive areas).	Urban pressure	Yes
WORSENING OF SOCIAL CONDITIONS IN THE COUNTRY (POPULATION)		
High aging rate and low birth rate at national level, with consequences on the generation renewal deficit.	Poulation over 65 years	Yes

Table 7 - List of "Threats" from the SWOT analysis that have a spatial expression

6.4.1 Urban Pressure

6.4.1.1 Urban pressure

Sintra's territory has been under the threat of excessive and unsustainable urban pressure for many years, especially in areas of high landscape value. In fact, as we can see from the map of the concentration of new dwellings built between the years 1991-2011 several areas of high environmental and landscape value were either invested or threatened by a growing construction of dwellings. It is the case of many coastal areas (like Praia das Maçãs, Almoçageme, Praia Grande) but also areas around the Serra de Sintra and the urban axis.

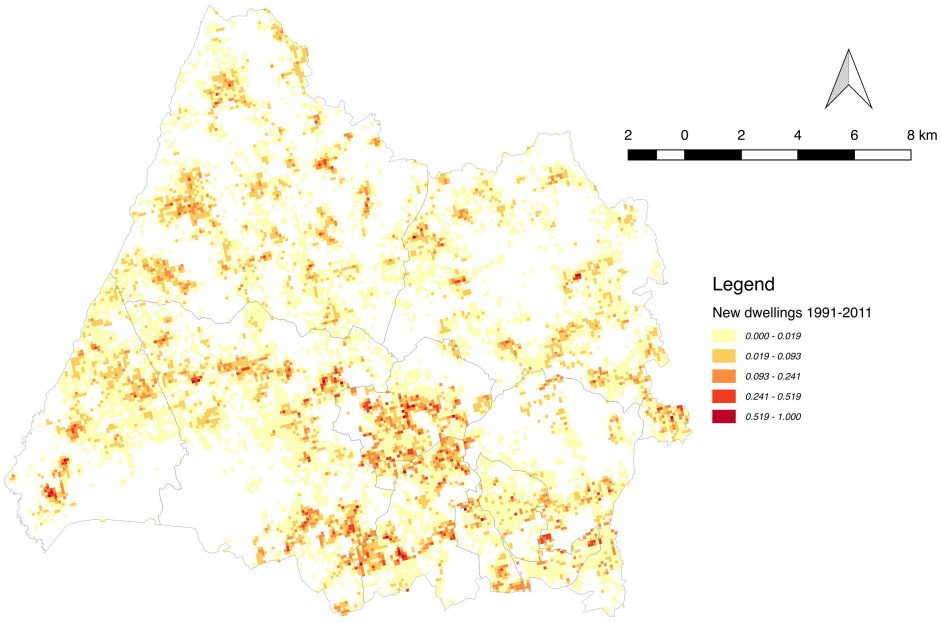

Figure 62 – Mapping of the new dwellings built between 1991-2011

6.4.2 Worsening of social conditions in the country (population)

6.4.2.1 Population over 65 years

As we can see from Figure 63 the concentration of those locations where the share of population over 65 years old is higher, many places scattered throughout the territory are displaying high values. But in general the urban axis does not display the highest values, while the rural centers of the most remote areas of the municipality show the highest values.

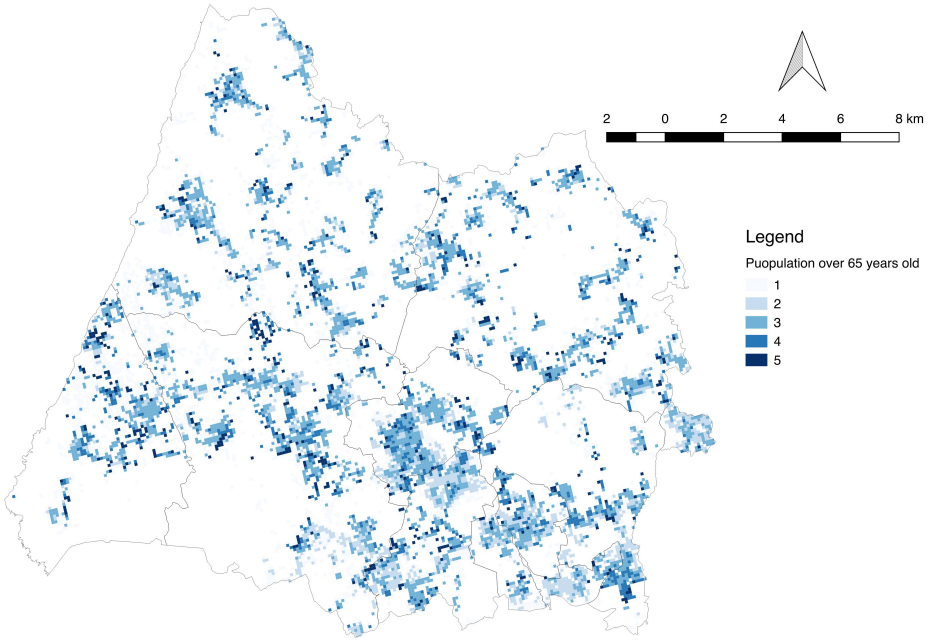

Figure 63 – Population over 65 years old

6.5 SWOT analysis summary

By spatializing the SWOT analysis created in the context of the revision of the PDM of Sintra, we obtain a quick overview on Sintra's SWOT items gaining some valuable insights on how the whole territorial system works and most importantly where its strengths, weaknesses, opportunities and threats are to be found.

As one can imagine, this is just an analytical tool with the sole aim of facilitating the visualization – hence the understanding – of the territorial dynamics of Sintra. In its simplest form, one can look at each item of the SWOT analysis separately or can start to look at spatial patterns and correlations between them. What we learned from this experiment is that, although the use of such visualization method is limited by several factors like the very nature of the indicator that has to possess a spatial expression, the availability of data and subjective interpretation of the SWOT item description, this method can deliver fast and easy to read visualization that can be shared across experts of different disciplines and with stakeholder in order to support in the decision-making process of territorial planning.

6.5.1 Spatial patterns of SWOT items

Here we present the spatial patterns that emerged from the grouping of the SWOT spatializations by category (Strenghts, Weaknesses, Opportunities and Threats). For decision makers and stakeholder it is important to visualize where the Strenghts, Weaknesses, Opportunities and Threats of the territory are located.

As we can see from a first look, the Strenghts that we managed to analyse are mostly concentrated along the urban axis, in the Vila de Sintra, or places like Almoçageme,

Praia Grande, Praia da Maçãs or also Belas, Casal de Cambra and Beloura. As you can notice a few items of the Strengths group has been left out from this visualization either because they had features too spread out (like the case of the vegetation resources, they were everywhere) either because we intended that they were not enough relevant for constituting an important feature or their distribution not enougn interesting to constitute a valuable addition to this mapping (like in the case of the creative and cultural industry locations). By looking at Figure 64 one can see how we decided to visualize only the highest classes of values for each SWOT item. For example, for the Human Capital we visualized the highest class of population with education levels ISCED 5-8 (the areas that correspond to the greatest concentration of them) and the lowest two classes of the Aging Index values (showing in this way the areas where the concentration of young population is higher).

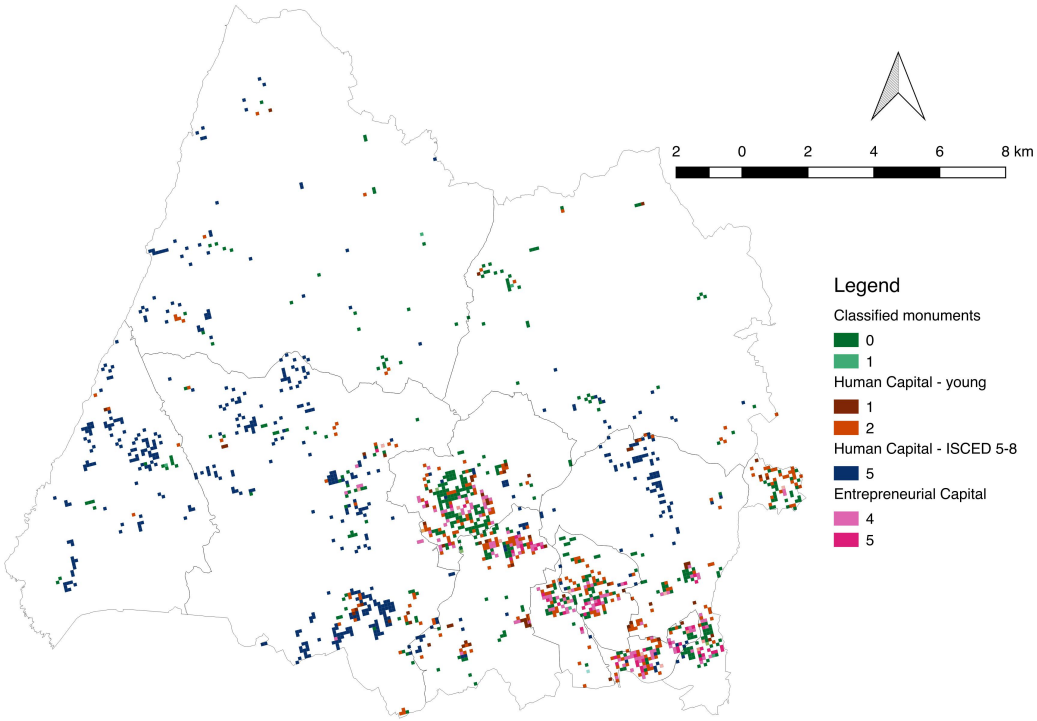

Figure 64 - Strenghts spatialized

For what concerns the Weaknesses items (Figure 65) we see a distribution that is much more spread out and that has a larger footprint on the dispersed areas of Sintra's territory. It is interesting to notice how the aging population displays a similar distribution as the indicators of suburban characteristics and monofunctionality. On the other hand the empty dwellings share over the entire buildings reaches its peak in some peripheral locations along the urban axis.

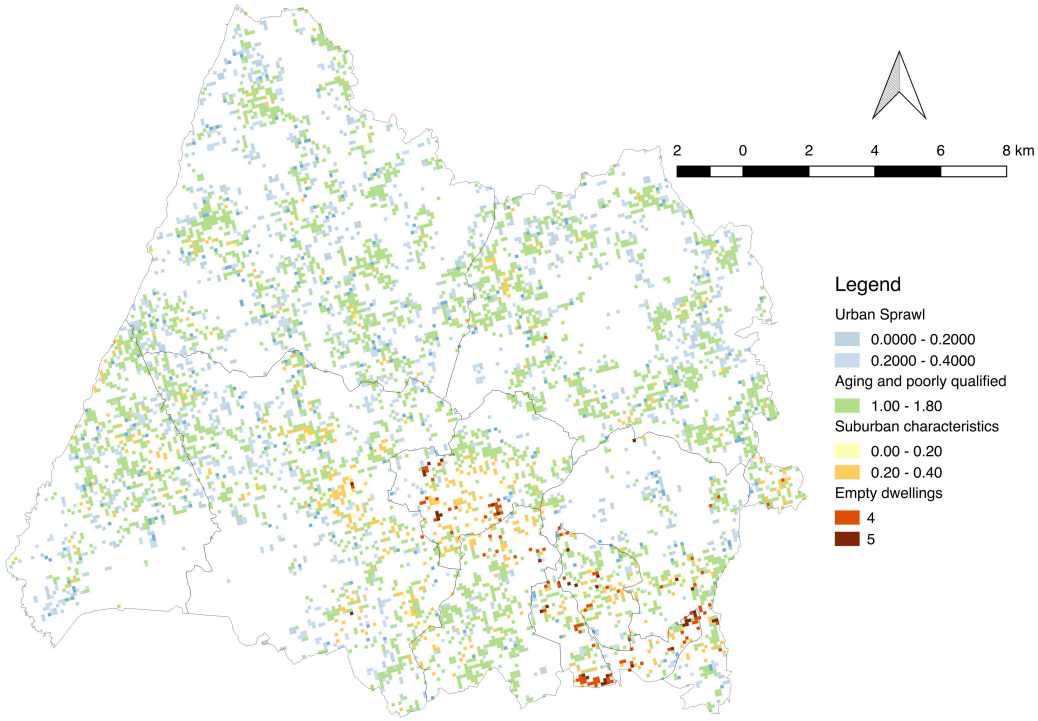

Figure 65 - Weaknesses spatialized

In terms of opportunities (Figure 66) we only had one item to visualize, the high connectivity and proximity with Lisbon. Such item has been visualized by means of network analysis. Here we present the result of Integration 5km radius that shows how the urban axis with its highways and fast connection roads to Libon is the most connected with the capital city.

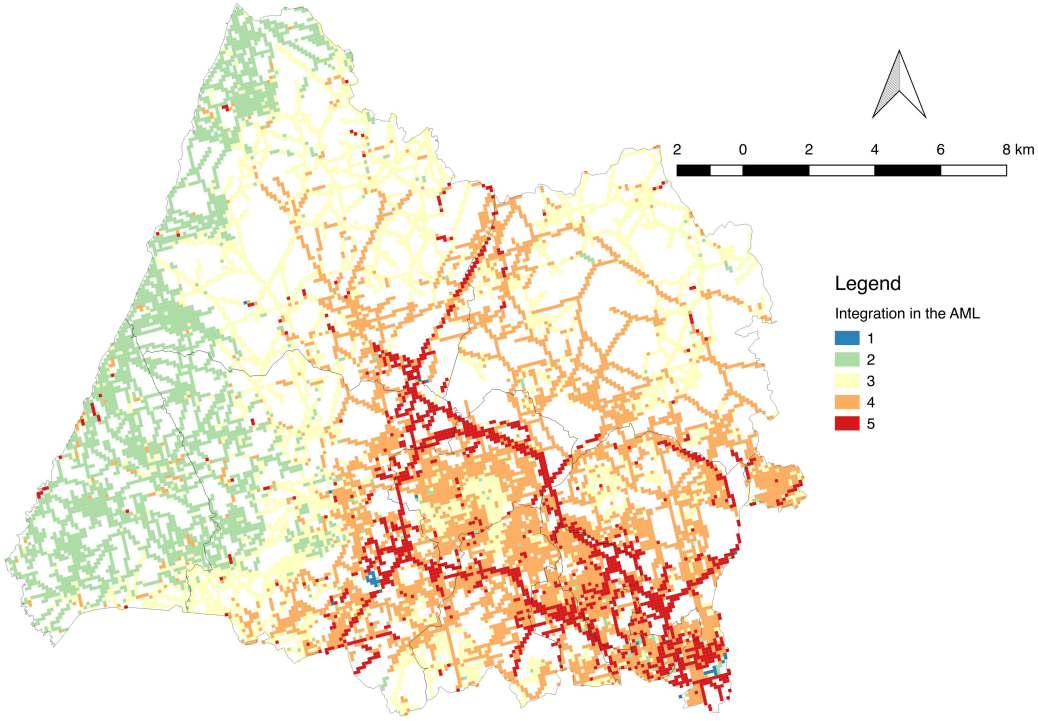

Figure 66 – Opportunities spatialized

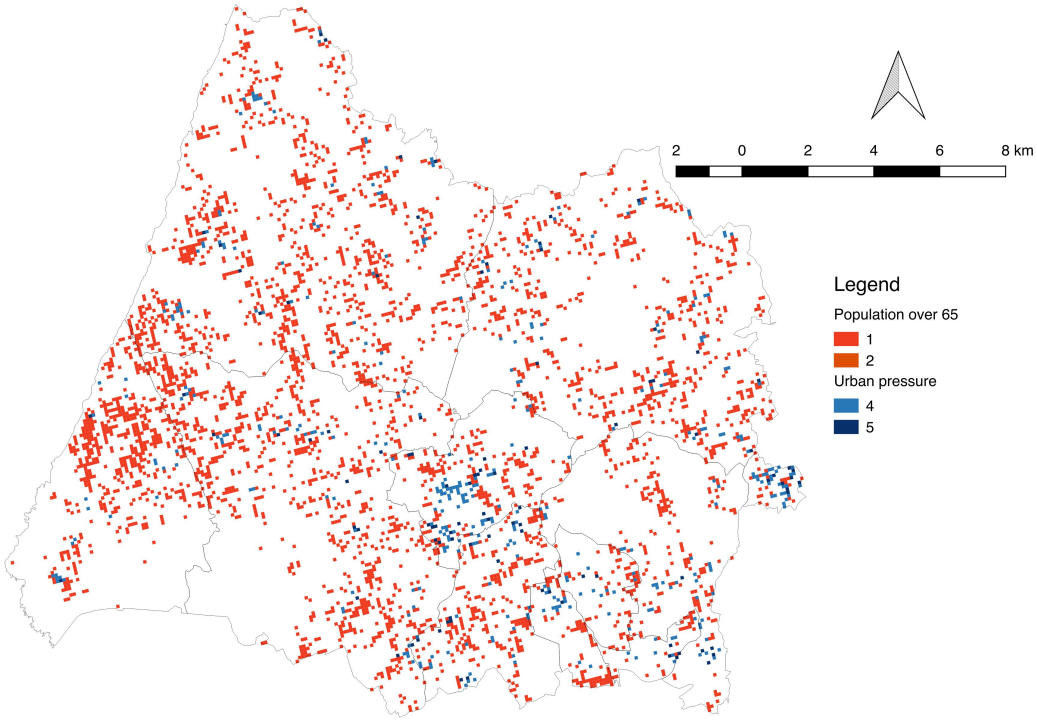

Figure 67 – Threats spatialized

On the other hand the Threats group (Figure 67) display again a more wide-spread distribution being especially the distribution of the highest classes of population over 65 years old very dispersed. Here the zones of the Atlantic coast of Sintra around Praia Grande and Praia das Maçãs are the ones affected the most.

7. DEVELOPMENT SCENARIOS EVALUATION

The second phase in which a model like the one proposed in the present work can be employed in the context of definition or update of a master plan is during a scenario evaluation phase. In order to evaluate different development scenarios, and to be able to test them and compare them one against the other, a profiling for each portion of the municipal territory is needed. Such profiling, being constituted by a precise range of values for a specific set of indicators, allows for the objective comparison of one location against the other for a specific scenario.

In the case of Sintra, the latest update of the municipal masterplan included a Territorial Development Model (MDT) that incorporated in the plan a prospective of what the planners and the municipal administrators wished for or expected for Sintra in the mid-term to long-term future.

Such a document embodies the holistic approach used in the revision of the PDM of Sintra as well as the systemic thinking involved.

Thus, the Territorial Development Model of Sintra sought to synthesize strategic axes and potential policies for specific territorial units of Sintra's municipality that share similarities and therefore were amenable to be treated in a common way. The model also establishes the necessary connections for the system (city / territory) to function in the most efficient way.

Such Territorial Development Model in many respects obeys the rules of a scenario planning system, being a strategic planning method that is used to make flexible long-term plans.

Scenario planning may involve aspects of systems thinking, specifically the recognition that many factors may combine in complex ways to create sometime surprising futures (due to non-linear feedback loops). Systems thinking used in conjunction with scenario planning leads to plausible scenario storylines because the causal relationship between factors can be demonstrated. In these cases, when scenario planning is integrated with a systems thinking approach to scenario development, it is sometimes referred to as dynamic scenarios.

The Territorial Development Model of Sintra establishes areas (or territorial units) whose objectives are coincident, and to which specific scenarios are assigned.

Thus, the following units are identified:

a) Polycentric city;

b) Specialized economic zone;

c) Mountains;

d) Atlantic rurality;

e) Urban seafront;

f) Agricultural interior;

The Development Scenario Evaluation task that is present here aims at assessing, computing and mapping the functional patterns that derive from the definition of specific development scenarios and development goals set by the Municipality of Sintra, combining them with the specific context. This constitutes a way to develop a scenario planning strategy and to incorporate this in the debate over Sintra's strategic decisions.

Our contribution to the Model is to add a layer of information – the proposed territorial profiling - able to quickly and intuitively identify areas with specific vocations and potentialities that could render the whole system of Sintra's territory more competitive and diversified

In this work we concentrated on the strategic goal of the municipality expressed in the PDM revision of making Sintra a more polycentric territory, trying to formulate development scenarios in line with the ones proposed by the PDM of Sintra and assessing the potential for such scenarios in different locations based on their territorial capital.

7.1 Polycentric territory scenarios

The growth of the Lisbon Metropolitan Area during the last decades contributed to the rise unbalanced relationships the surrounding municipalities and the city of Lisbon. In fact, the macrocephaly of the city of Lisbon over the surrounding territories contributed to delineating a territory composed of several satellite urban centers adjacent to the main city. The dynamics established between Lisbon and the peripheral nuclei reveal the omnipotence of the central city, around which the peripheral nuclei establish relations of excessive dependence and subservience with the main city.

The urban system of Sintra results from an adaptation to the overall context of the Lisbon Metropolitan Area already presented. Sintra's municipal area is characterized by a diverse concentration of different nuclei of different levels in the urban system hierarchy of Sintra, in which however the axis Lisbon-Sintra created by the infrastructural arteries plays a central role. Nevertheless, the resulting territory is highly dispersed and fragmented. Such fragmentation highlights the need for a functional and morphological concentration that should happen in those nuclei that are able to "step up" from one level to another by strengthening their centrality and diversification of uses. This does not detract from the reinforcement of those who remain, but seeks essentially to balance the territory, creating more centralities and reducing the commuting movements.

The urban axis is divided by the municipal ecological structure into four nuclei or cities:

- two of which (Sintra and Agualva Cacém) are eminently administrative because they have the conditions to support essential public services,
- and the other two (Algueirão Mem Martins and Queluz Massamá) should seek public space and urban environment, and improve their diversity (uses), contributing to greater resilience and population fixation (more employment and reduction of commuting), turning them into balanced and attractive cities (something that the first level / administrative level also have to ensure).

Sintra's urban axis, because of its origin and nature, is relatively delimited between IC19 and A16, although it also covers less structured territories between IC19 and A5.

The urban axis corresponds to urban areas, consolidated, infrastructures and equipped, although there is a significant deficit in the supply of qualified public spaces and green spaces of collective use (absence of spaces that create and develop identity processes and that contribute to the quality of life). These are spaces that must be treated at the macro level (integrating cities into a broader system) and at the micro level (urban requalification / "urban acupuncture"). The intervention is essential, since the main "critical mass" of the county (the population) is concentrated here.

The southern zone of the urban axis corresponds to the multifaceted and not completely stabilized, organized and consolidated territories south of the IC19. They comprise residential and industrial zones that are considered as poles (some quite important) relatively dispersed, without special territorial logic. In this area, the industrial and business triangle Abrunheira / Albarraque and the Science and Technology Park of the Lisbon Region stand out, with the use of existing synergies with Tagus Park and the existing infrastructures on site (former Univ. UCP).

For this purpose, objectives have been defined:

a) Creation of conditions for the reinforcement of the centralities, through the diversification of uses (combating the residential mono-functionality) and the requalification of the central urban spaces;

b) Improvement of the quality of life of the population (public space, equipment, green spaces, infrastructure, social support, transport and mobility) through integrated interventions that progressively raise the quality standards of urban soil as a substrate of human activity;

c) To increase the competitiveness and attractiveness of the industrial and business poles, through their articulation, planning and research and development (constituting spaces essential for the creation of employment and retention of young and active population).

For such strategic axis of Sintra's territorial development we formulated a few scenarios that resulted in a territorial mapping that can be used as a support for decision-making process in the context policy definition and strategic planning for different part of Sintra's territory. The goal of this phase has been to implement a system that could render in a quick and intuitive way the results returned by the territorial analyses performed on the basis of our indicators and using as a reporting layer the territorial grid 100x100m proposed in this work.

7.1.1 Scenario 1: Lively Urban Centers

The first profile we identified in the Polycentric city theme is what we called Lively Urban Centers. Such profile would give us an overview of the locations in the territorial grid of Sintra that correspond to a more lively urban character.

Taking from the literature about urban centers character and liveness of urban conglomerates, what we intended to be crucial to identify a lively urban center have been:

- a value of population density not lower than a minimal threshold that would identify the minimal critical mass needed to form an urban center

- a relatively high GSI value (as a sign of intensity of land occupation and therefore building density)

- a value of empty apartments not too high (as it would signify that the area is not that active on the real estate market)

- a very high value in urban compactness (as a proof that the location is a compact urban center)

- a pretty high Mixed Use Index (Simpson's Index) that would signify a diversified and lively economic and social fabric

- a sufficiently high number of activities of the tertiary sector (as a sign of developed service economy and high rates of commercial activity)

- a sufficiently high road network density stemming from a dense urban pattern

- choice and integration value in 5km radii were not taken into account in this profile

We summed up those indications to a sequence of scores of selected indicators as shown in the following filter expression:

"pop_ha_scale_normal" >=2 AND

"GSI_scale_normal" > 2 AND

"fogos_vagos_share_scale" < 4 AND

"dispersion_index_scale" = 5 AND

"simpson_index_scale" >= 3 AND

"num_act_ter_scale_share" >= 2 AND

"allroard_l_normal_scale" >= 2 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 1

Each one of these conditions had to be met in order for a specific grid cell to be considered part of the Lively Urban Center territorial profile. So, such profiling framework acts as a filtering criteria to determine whether or not a certain grid cell is part of the current profile or not. Such filtering would allow us to visualize directly on the map the locations within Sintra's territory that meet the criteria for the given profile.

These areas are urban centers that display a high amount of economic activity of the tertiary sector as well as good level of mixed use proving to be very interesting to people and to services. Being interesting to people as places to live makes them also have a low degree of empty dwellings, proving once again their success from a residential and commercial point of view (Figure 69).

The profile previously described as filtering expression in Qgis has been also visualized as radar chart for a more intuitive comprehension. Here the same sequence of scores previously presented as filtering list is represented in a visual way by means of radar chart (Figure 68).

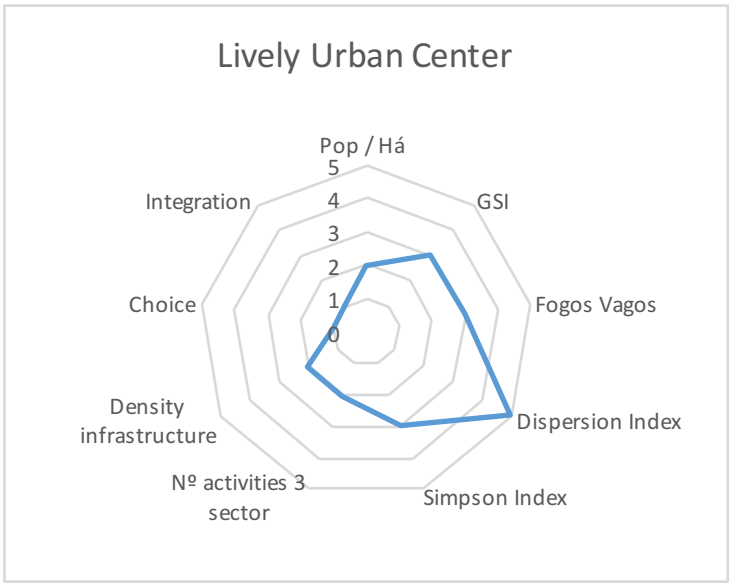

Figure 68 - Radar chart of Lively Urban Centers territorial profile

Such profiling operation leads to a graphic output that is easy to understand and to communicate and that constitutes a good output to deliver to local stakeholders and municipal administrators for policy making and discussion.

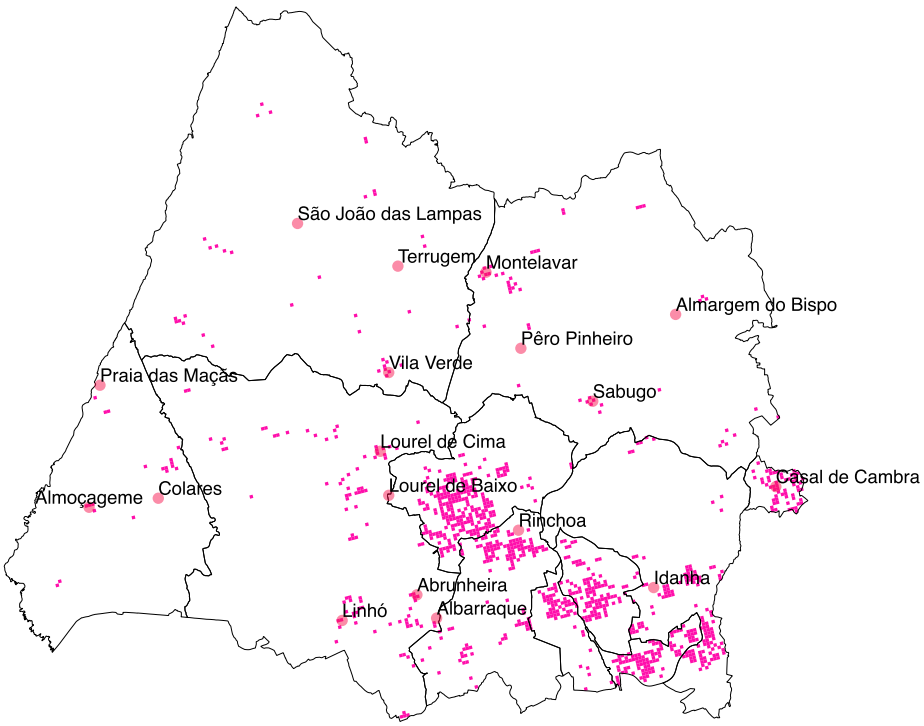

Figure 69 – Mapping of Lively Urban Centers

Looking at the results of such territorial profiling, it clearly shows a recurrent trend: the oldest urbanized nuclei of the urban axis that rose along the the railway line Sintra-Lisboa are the one that showed a higher concentration of locations falling under the profile “Lively Urban Canters”. Those locations are mainly present in Mira-Sintra, Algueirão-Mem-Martins and Queluz.

7.1.2 Scenario 2: Not Lively Urban Centers

The second profile we identified in the Polycentric city scenario is what we called Not lively urban centers. Such profile would give us an overview of the locations in the territorial grid of Sintra that correspond to urban centers yet with less lively character this time.

Taking from the literature about urban centers character and liveness of urban conglomerates, what we intended to be crucial to identify a lively urban center have been:

- a value of population density not lower than a minimal threshold that would identify the minimal critical mass needed to form an urban center

- a relatively high GSI value (as a sign of intensity of land occupation and therefore building density)

- a value of empty apartments not too high (as it would signify that the area is not that active on the real estate market)

- a very high value in urban compactness (as a proof that the location is a compact urban center)

- a pretty low Mixed Use Index (Simpson’s Index) that would signify a non-diversified and not lively economic and social fabric

- a sufficiently high number of activities of the tertiary sector (as a sign of developed service economy and high rates of commercial activity)

- a sufficiently high road network density stemming from a dense urban pattern

We summed up those indications to a sequence of scores of selected indicators as shown in the following filter expression:

"pop_ha_scale_normal" >=2 AND

"GSI_scale_normal" > 2 AND

"fogos_vagos_share_scale" < 4 AND

"dispersion_index_scale" = 5 AND

"simpson_index_scale" <= 2 AND

"num_act_ter_scale_share" >= 3 AND

"allroard_l_normal_scale" >= 2 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 1

If these conditions are met, the specific grid cell would then be considered as Not Lively Urban Center. These are areas where although there is a high concentration in terms of land occupation and total population (Figure 71),

The profile previously described as filtering expression in Qgis has been also visualized as radar chart for a more intuitive comprehension. Here the same sequence of scores previously presented as filtering list is represented in a visual way by means of radar chart (Figure 70).

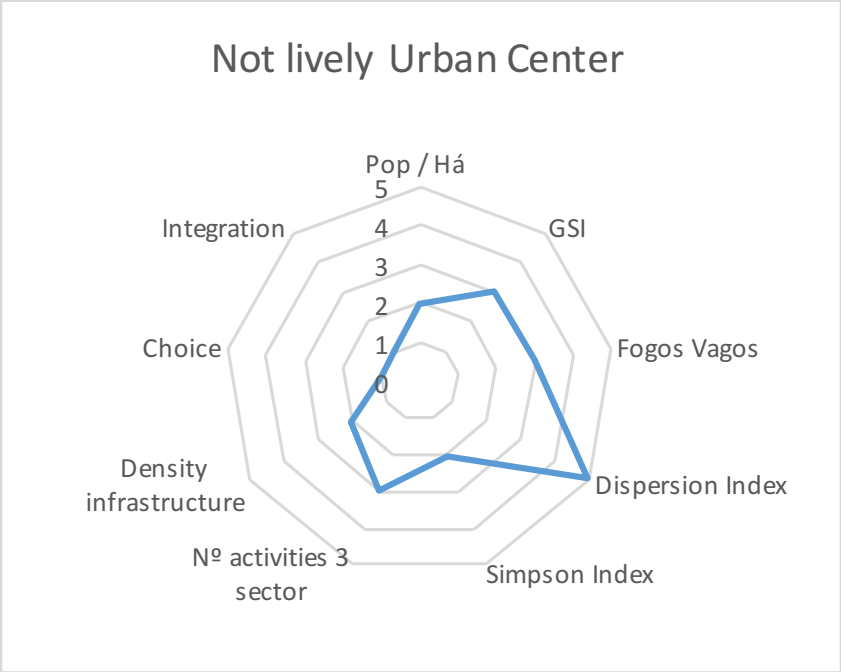

Figure 70 - Radar chart of Not Lively Urban Centers territorial profile

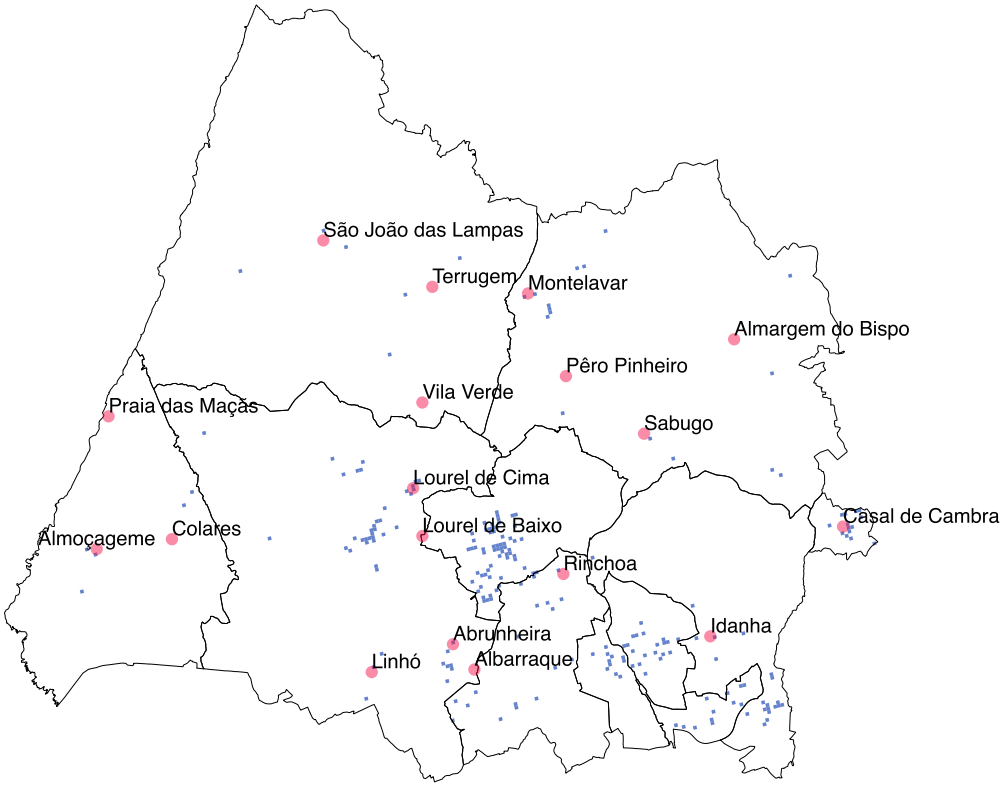

Figure 71 - Mapping of Not Lively Urban Centers

7.1.3 Scenario 3: Lively Dispersed Areas

The third profile we identified in the Polycentric city theme is what we called Lively dispersed areas. Such profile would give us an overview of the locations in the territorial grid of Sintra that correspond to dispersed areas that have a lively character.

Taking from the literature about urban centers character and liveness of urban conglomerates, what we intended to be crucial to identify a lively urban center have been:

- the values of population density and GSI were not taken into account in this profile

- a relatively high GSI value (as a sign of intensity of land occupation and therefore building density)

- a value of empty apartments not too high (as it would signify that the area is not that active on the real estate market)

- a value in urban compactness not too high (as a proof that the location is a dispersed area)

- a sufficiently high Mixed Use Index (Simpson's Index) that would signify a diversified and lively economic and social fabric

- a sufficiently high number of activities of the tertiary sector (as a sign of developed service economy and high rates of commercial activity)

We summed up those indications to a sequence of scores of selected indicators as shown in the following filter expression:

"pop_ha_scale_normal" >=1 AND

"GSI_scale_normal" >= 1 AND

"fogos_vagos_share_scale" < 4 AND

"dispersion_index_scale" < 4 AND

"simpson_index_scale" >= 2 AND

"num_act_ter_scale_share" >= 2 AND

"allroard_l_normal_scale" >= 1 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 1

If these conditions were met, the specific grid cell would then be considered as Lively Dispersed Area (Figure 73).

There are areas of dispersed urbanization where nevertheless there are positive degrees of diversity index and good amount of economic activities of tertiary sector. This together with a relatively low rate of empty dwellings signifies that the area is a popular choice for residents and attract service economy as well.

The profile previously described as filtering expression in Qgis has been also visualized as radar chart for a more intuitive comprehension. Here the same sequence of scores previously presented as filtering list is represented in a visual way by means of radar chart (Figure 72).

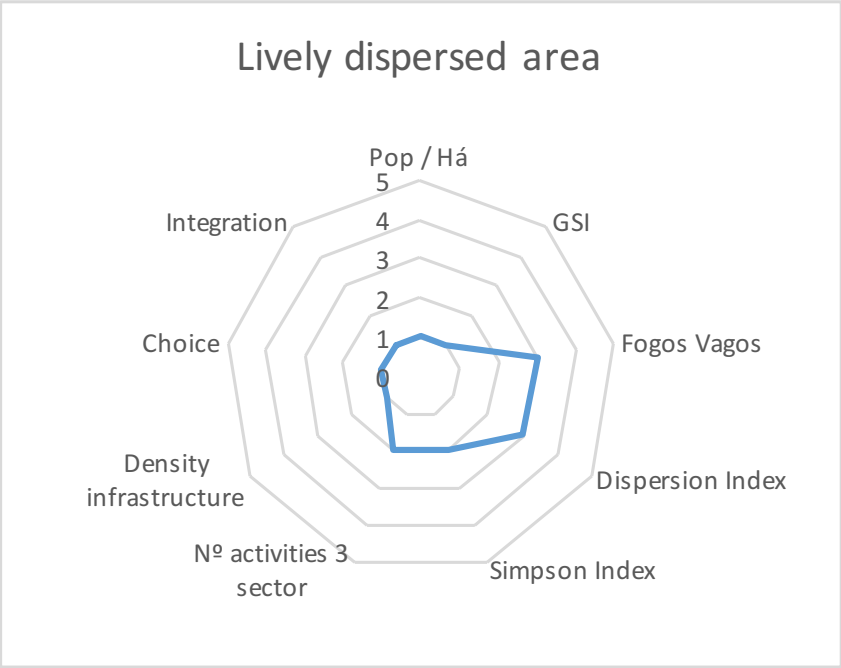

Figure 72 - Radar chart of Lively Dispersed Area territorial profile

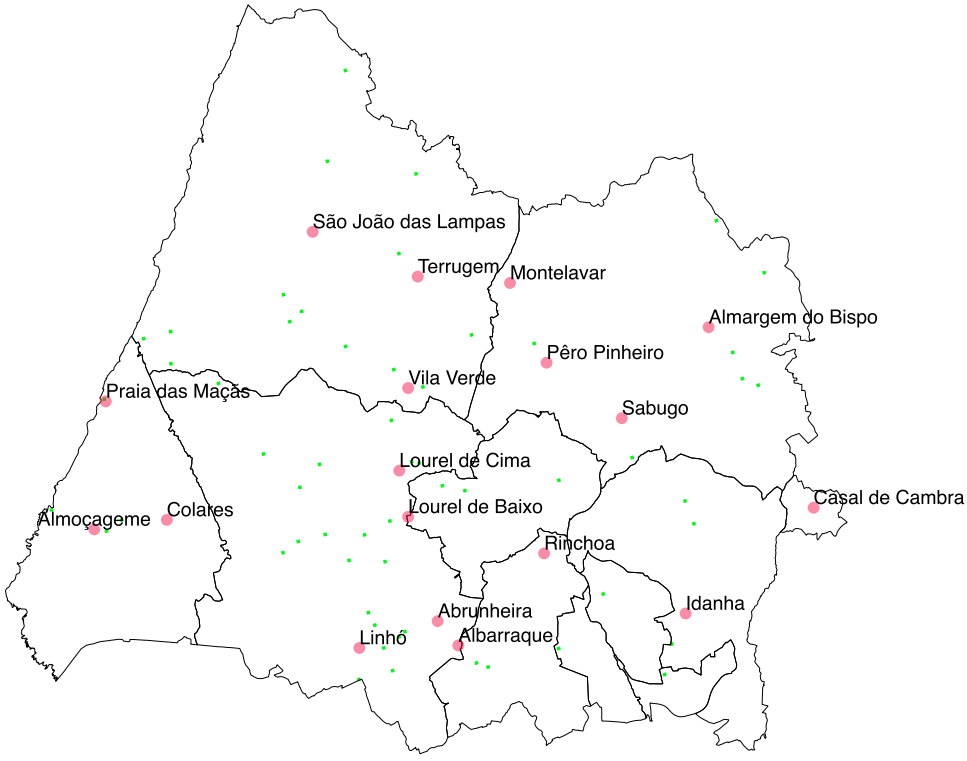

Figure 73 - Mapping of Lively Dispersed Areas

7.1.4 Scenario 4: Not Lively Dispersed Area

The fourth profile we identified in the Polycentric city theme is what we called Not lively dispersed area. Such profile would give us an overview of the locations in the territorial grid of Sintra that correspond to dispersed areas but with a less lively character, this time.

Taking from the literature about urban centers character and liveness of urban conglomerates, what we intended to be crucial to identify a lively urban center have been:

- the values of population density and GSI proved to be irrelevant for this profile

- the value of empty apartments was not taken into consideration in this profile

- a value in urban compactness not too high (as a proof that the location is a dispersed area)

- a sufficiently low Mixed Use Index (Simpson's Index) that would signify a non-diversified and not lively economic and social fabric

- a sufficiently low number of activities of the tertiary sector (as a sign of underdeveloped service economy and low rates of commercial activity)

We summed up those indications to a sequence of scores of selected indicators as shown in the following filter expression:

"pop_ha_scale_normal" <= 2 AND

"GSI_scale_normal" <= 2 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" <= 3 AND

"simpson_index_scale" <= 3 AND

"num_act_ter_scale_share" <= 3 AND

"allroard_l_normal_scale" >= 1 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 1

If these conditions were met, the specific grid cell would then be considered as Not lively Dispersed areas (Figure 75).

The profile previously described as filtering expression in Qgis has been also visualized as radar chart for a more intuitive comprehension. Here the same sequence of scores previously presented as filtering list is represented in a visual way by means of radar chart (Figure 74).

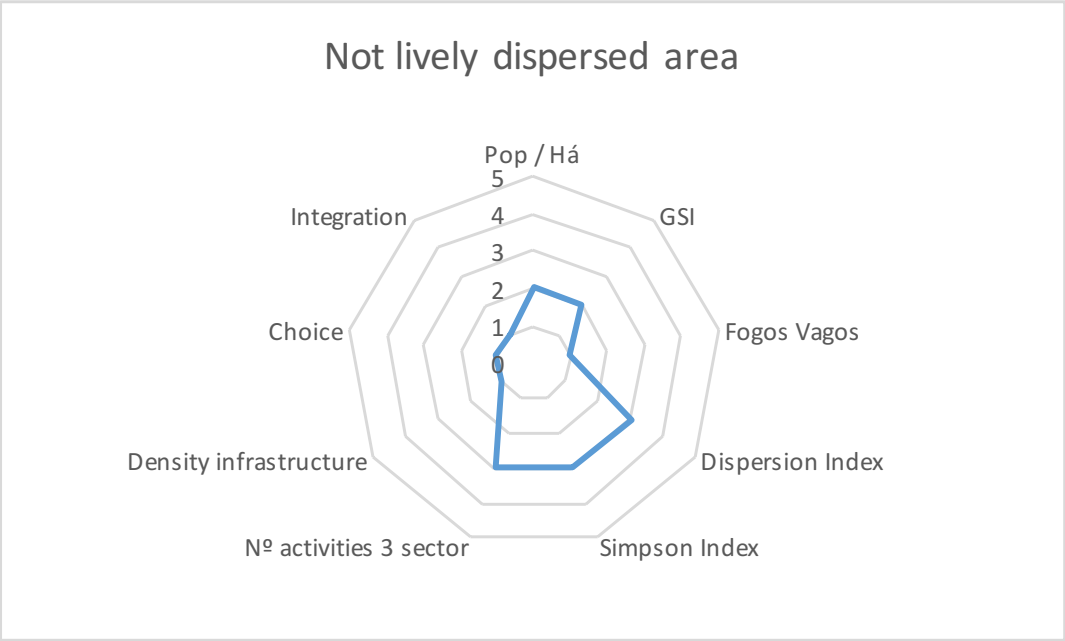

Figure 74 - Radar chart of Lively Dispersed Area territorial profile

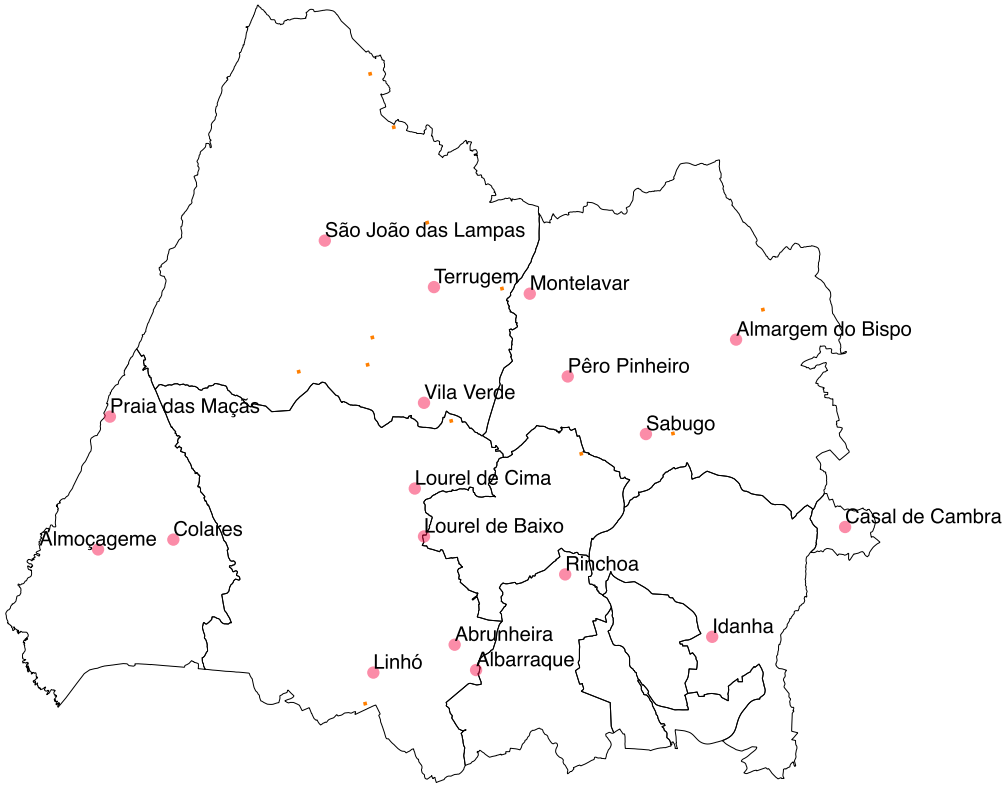

Figure 75 - Mapping of Not Lively Dispersed Area

7.1.5 Scenario 5: Dispersed Area with Potential to Become Place

The fifth profile we identified in the Polycentric city theme is what we called Dispersed Area with Potential to Become a Place. Such profile would give us an overview of the locations in the territorial grid of Sintra that correspond to a dispersed area but have the potential to attract some sort of urbanity and turn into a "place".

Taking from the literature about urban centers character and liveness of urban conglomerates, what we intended to be crucial to identify a lively urban center have been:

- a rather low population density (as this would prove that it is a dispersed area)

- a relatively low GSI value (as a sign of low intensity of land occupation and therefore building density)

- a sufficiently high value of choice and integration at 5km radii, signifying that the location has both the potential of being a central place in the through-movement patterns and in the to-movement patterns.

- a pretty low value in dispersion index (as a proof that the location is a dispersed area)

We summed up those indications to a sequence of scores of selected indicators as shown in the following filter expression:

"pop_ha_scale_normal" <= 2 AND

"GSI_scale_normal" <= 2 AND

"choice_r5k_norm_scale" >= 2 AND

"integr_r5k_norm_scale" >= 2 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" <= 3 AND

"simpson_index_scale" >= 1 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 1

If these conditions were met, the specific grid cell would then be considered as a dispersed area with potential to become a place (Figure 77).

The profile previously described as filtering expression in Qgis has been also visualized as radar chart for a more intuitive comprehension. Here the same sequence of scores previously presented as filtering list is represented in a visual way by means of radar chart (Figure 76).

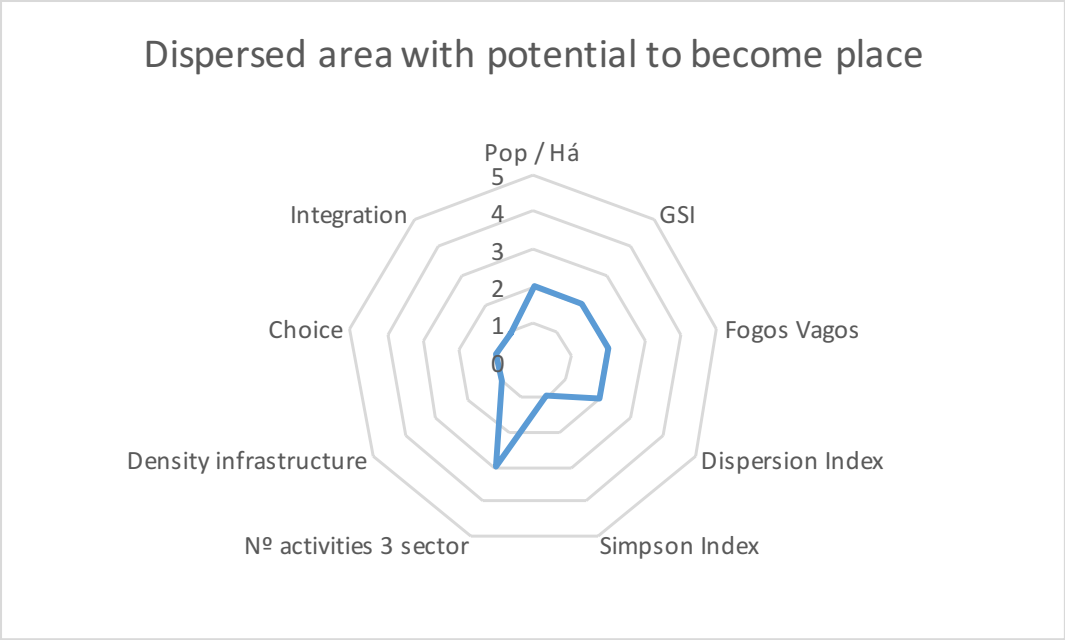

Figure 76 - Radar chart of Dispersed Area with Potential to become Place profile

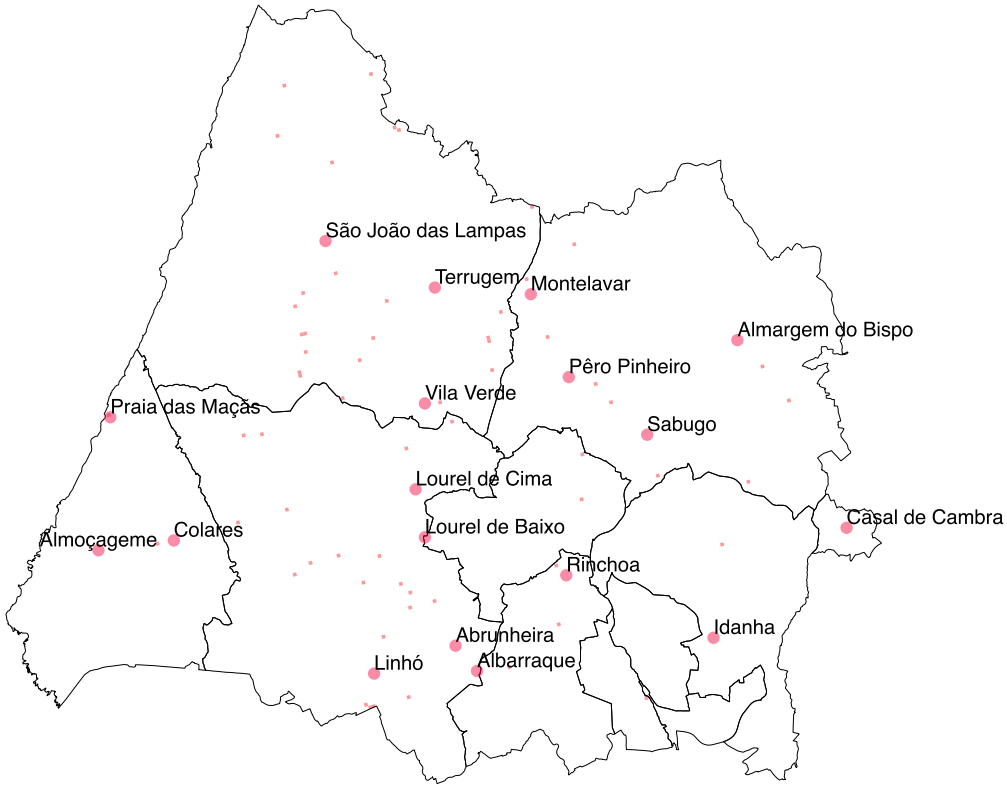

Figure 77 - Mapping of Dispersed Area with Potential to Become Place

7.1.6 Scenario 6: Dispersed Area with Potential to Become Node

Another profile that we identified in the Polycentric territory theme is what we called Dispersed Area with Potential to Become a Node. Such profile would give us an overview of the locations in the territorial grid of Sintra that correspond to urban centers but with less lively character, this time. The concept of node comes from Bertolini's studies of railway networks (1996). We took this concept generally used in the area of TOD to exemplify the differences between a location with a strong vocation for being a transportation node and a location that, on the contrary, has a vocation for being a place, carrying a sense of "urbanity" and being more capable of attracting urban functions and residents.

Taking from the literature about urban centers character and liveness of urban conglomerates, what we intended to be crucial to identify a lively urban center have been:

- a relatively low GSI value (as a sign of low intensity of land occupation and therefore building density)

- a pretty low value in dispersion index (as a proof that the location is a dispersed area)

- a very high value of choice at 5km radius, signifying that the location is a central place in the through-movement patterns

We summed up those indications to a sequence of scores of selected indicators as shown in the following filter expression:

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" <= 2 AND

"fogos_vagos_share_scale" >= 1AND

"dispersion_index_scale" <= 4 AND

"simpson_index_scale" >= 1 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 1AND

"choice_r5k_norm_scale" >= 4 AND

"integr_r5k_norm_scale" >= 1

If these conditions were met, the specific grid cell would then be considered as a dispersed area with potential to become a node (Figure 79). The profile previously described as filtering expression in Qgis has been also visualized as radar chart for a more intuitive comprehension. Here the same sequence of scores previously presented as filtering list is represented in a visual way by means of radar chart (Figure 78).

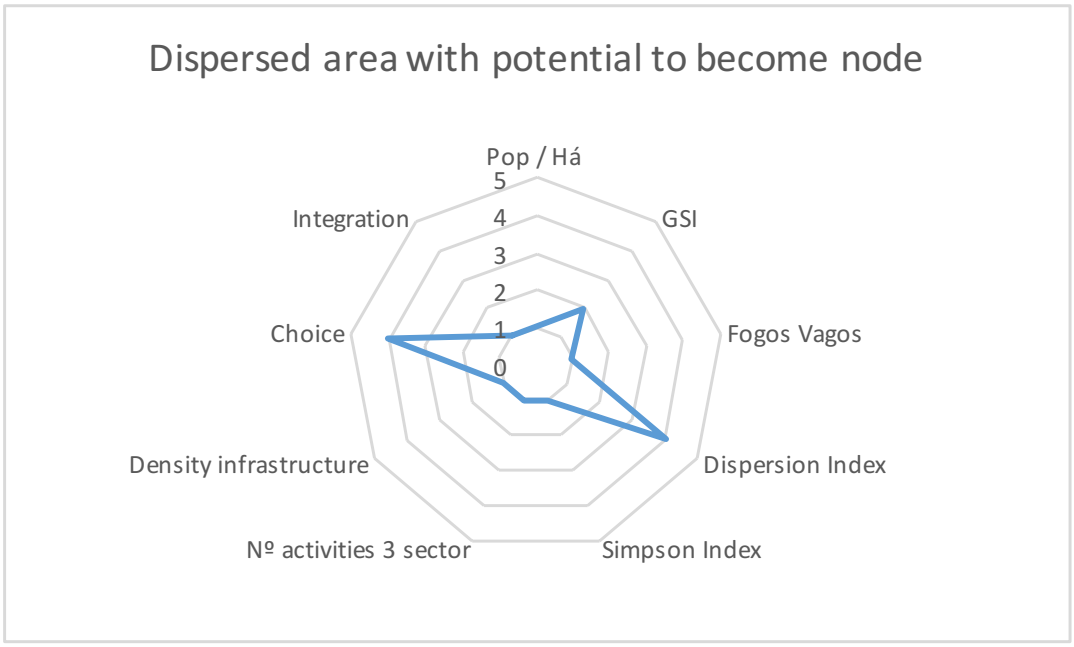

Figure 78 - Radar chart of Dispersed Area with Potential to Become Node profile

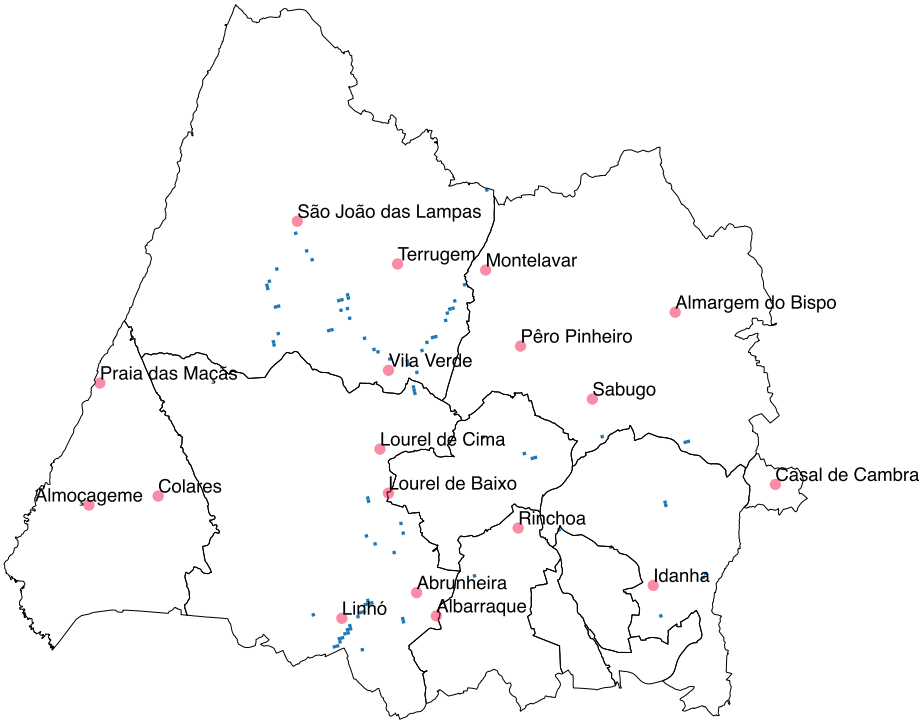

Figure 79 - Mapping of Dispersed Area with Potential to Become Node

7.1.7 Polycentric territory development scenario overview

From an overview of the entire urban system of Sintra, it is possible to see how different locations require different treatment in order to achieve a polycentric city.

In the case of Pêro Pinheiro, for example, there are conditions to regain centrality if population can be fixed. While on the other hand, Paiões, Varge Mondar and Mercês are at risk of losing centrality, as their hierarchical position depends largely on Population and Land Occupation indicators (which reveals a poorly qualified territory in terms of centrality).

The end result of such territorial profiling is an overview of the urban system of Sintra where it is evident how the mono-functionality of the residential areas is broken from time to time by the existence of some nuclei (especially of medium size) where the presence of industrial and business activities mitigates the mono-functionality of the place. Here a mix of uses can promote the anchoring of novel functions in a balanced way promoting the creation of a more self-contained, sufficient and sustainable urban corridor.

Outside the urban axis, the existence of small and medium-sized places with potential for some functional specialization (industrial / business or tourism) could contribute to increasing the link between the municipality's urban and rural areas, reducing the dependence on other municipalities (reducing the working commute) and contributing to the cohesion between the different areas of the municipality, and even to the reinforcement of the municipality's identity.

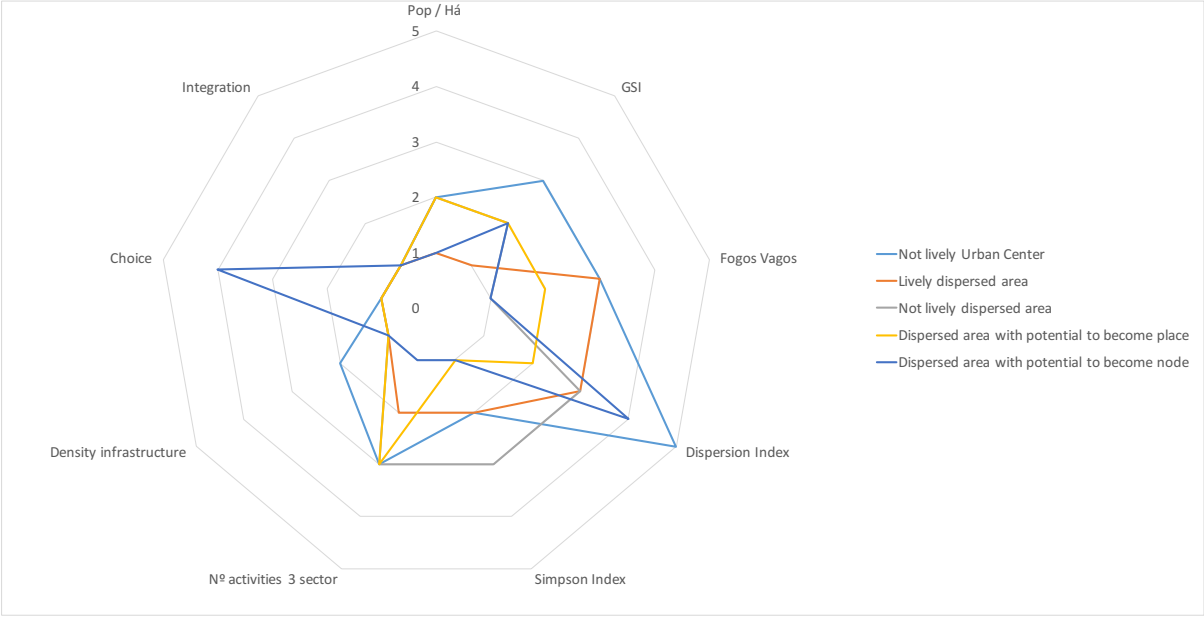

Figure 80 – Group radar chart of all the territorial profiles together

8. DISCUSSING THE RESULTS OF THE SWOT SPATIALIZATION

In this work we aimed at that designing, building and experimenting a methodological and operative framework that can be used in various stages of a process of developing or revising a municipal masterplan or regional development plan. Such framework, bringing a standardized and comparable reporting grid, supports the implementation of two territorial analysis tools to be used in two different stages of a planning process:

- one is the spatialization of the SWOT analysis, as we have seen in the previous paragraphs,
- the other is the territorial profiling used to perform a development scenario evaluation that we will illustrate here.

In the present work, in fact, we present an analytic model capable of guiding through the process of designing and implementing a municipal or regional development plan, incorporating datasets and strategic considerations from different realms into a single framework. The two examples of practical applications of the model that we present here can be used in the real-world planning practice – for example in the revision of a municipal masterplan, as described in the previous chapter.

These two applications – the SWOT analysis spatialization and the territorial profiling for the development scenarios evaluation phase – returned a series of results later mapped into a custom representation of the municipal territory based on a refinement of the territorial grid 1x1km proposed by the European Union.

In this chapter we will present the results of the two applications compared them with both the SWOT analysis and the scenarios put forward in the latest PDM revision of Sintra. The results will also be compared with the most relevant theories on urban dispersion, territorial capital and the concept of re-urbanization.

Our results will be tested here to check if there is a correspondence between them and the SWOT analysis performed in the context of the PDM revision and the development scenarios presented in the PDM.

The spatialization of the SWOT analysis has been the first application of the model that we proposed in this work. It allowed for a new look at territorial features and phenomena by giving them a spatial expression. In this way, by spatializing the SWOT analysis we were able to map its features on the custom reporting grid 100x100m. Following here we will give an overview of the results of such spatialization, comparing them with the elaborations made during the latest revision of the PDM by the municipality of Sintra.

8.1 Strengths

8.1.1 Exceptional heritage: a SWOT analysis discussion

Sintra is renowned for its exceptional heritage. As UNESCO World Heritage Heritage Site, Sintra displays a vast architectonical and archeological heritage, so we decided only to consider the classified heritage here, dividing it into architectural and archaeological.

Heritage has a double valence: not only it is a unique feature that signalizes important and central places (one of the features of central places is indeed to offer something that the other places do not offer), but also marks the territory, giving it identity and translating into a sense of belonging to the place by those who inhabit it.

In order to represent the relevance of the cultural heritage throughout the municipality of Sintra, we mapped the portions of Sintra's territory by density of classified monuments count – a layer of information that the municipality made available for us.

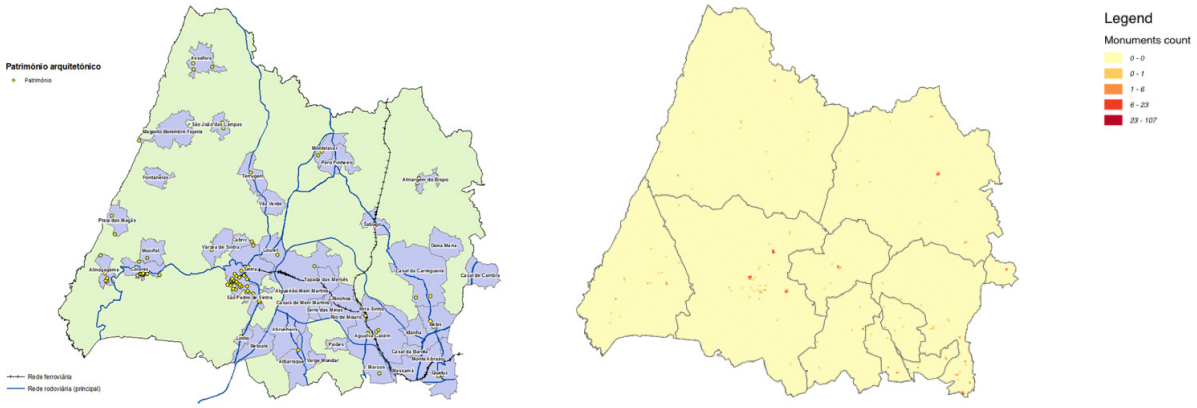

Figure 81 – Comparison of heritage map of Sintra's PDM (left) and monuments count mapped by us on the custom grid 100x100m (right)

By comparing the spatialization of the SWOT analysis item regarding the exceptional heritage with the corresponding mapping created by the municipality of Sintra for the revision of its PDM (see Figure 81) one thing is clear: that, even if the two mapping differ a bit in terms of features count, the exceptional heritage in Sintra is much more spread than one could initially imagine. In fact, as it turned out from our analysis, the

architectonical and archaeological heritage of Sintra is not to be found only in the Villa de Sintra or around its famous Serra. Surely, the area of Serra de Sintra sports one of the highest concentration of exceptional heritage sites but the striking fact is how the whole municipal area has its own heritage epicentres spread throughout its entire extents. Such epicentres are located in the central places that form the backbone of Sintra's traditional territorial structure: a meshwork of villages and clustered houses scattered over the rural territory located along or at the intersection of the traditional road arteries.

Places with particularly high number of exceptional heritage are Vila de Sintra, São Pedro de Sintra, but also Almargem do Bispo, Cabriz and area around Barata. It is interesting to notice how the presence of exceptional heritage relates to the distribution of urban centers, as highlighted by the map produced by the municipality in Figure 81.

8.1.2 Natural resources and enviromental quality: a SWOT analysis discussion

Sintra's territory is rich in geological resources, which over the centuries shaped both its landscape and its economy, and natural resource that constitute one of the main assets upon which the municipality is trying to build a new attractiveness in the attempt of creating a new (polycentric) green Sintra.

Looking at the geological resources, by comparing the data provided by the municipality about the location of the extraction sites on the municipal territory with the data provided by the Copernicus project, which returns a detailed land-cover mapping for the whole European Union, as in Figure 82, we were able to gain insights about one of the most important resources of Sintra's territory and economy: its stone. In fact, stone extraction and treatment has been traditionally one of the most important activities of Sintra's northern territory.

The presence of quarries and extractive sites here coexists since long time with industrial stone-cutting and stone-treatment facilities.

Clearly the majority of the cells invested by quarries are located in the area comprised between the centers of Pero Pinheiro and Montelavar, in the north-east part of the municipality, which is also an area characterized by a high concentration of industry – given its relatively low population levels.

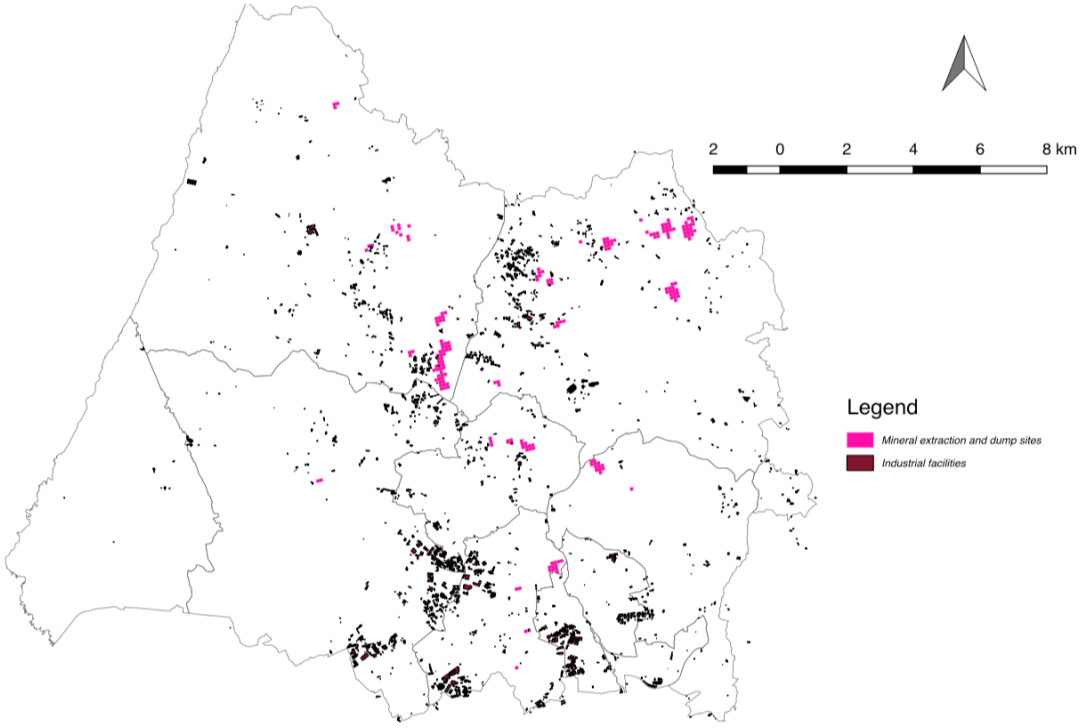

Figure 82 - Mapping of extraction site and industry concentration

Figure 82 shows that while the urban axis Lisbon-Sintra takes a center stage in the count of the existing productive activities, it is possible to gain a better understanding of the relationship between the extraction sites and the industrial cluster of Pêro Pinheiro, Montelavar and Maceira by looking the mapping that highlights the industrial facilities and the locations of extractive activities simultaneously. A clear juxtaposition of extractive and productive activities characterizes this area in the north-east part of the municipal area, giving rise to one of those "transgenic territories" (Domingues, 2013) where rural, urban and industrial activities coexists forming a novel kind of territory not rural nor urban.

The requalification of industrial zones such the ones of the Montelavar - Pêro Pinheiro - Maceira triangle as well as the qualification of forestry and agricultural resources will also serve to attract new investment and population.

On the natural resources side in fact, Sintra's territory is still characterized by a high percentage of areas covered by agriculture, agroforests and forests. By mapping the different kinds of natural surfaces land cover, it is possible to understand the strategic view of the latest revision of the PDM that states that Sintra wants to transform itself into a polycentric territory where the easy access to both urban and peri-urban green areas contributes to elevate the quality of life of the resident population.

As it is possible to see in the next mapping, Figure 83, the proximity between areas characterized by higher levels of land sealing (i.e. higher compactness) and green areas, either forests or urban green areas.

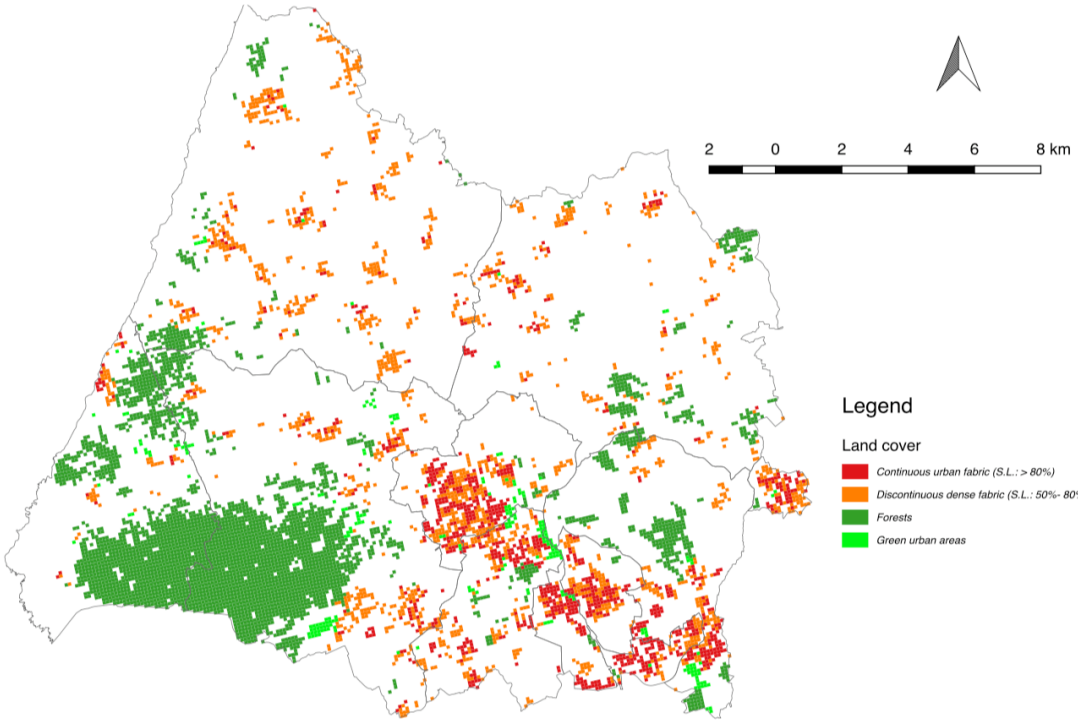

Figure 83 - Mapping of the land cover with green areas and most compact urban conglomerates

8.1.3 Population and human capital

Sintra is the second most populous municipality in Portugal with a multicultural, diverse, and young population, increasingly educated and qualified.

By comparing different mappings we will try to investigate here the relation between total population, age and levels of education. As highlighted by the figure below, a map of population density developed by the municipality of Sintra with data provided by the national Census of 2011 by the Instituto Nacional de Estatistica, the highest population densities are to be found along the urban axis that grew along the railway line Lisbon-Sintra. Beside this also Casal de Cambra displays a high population density.

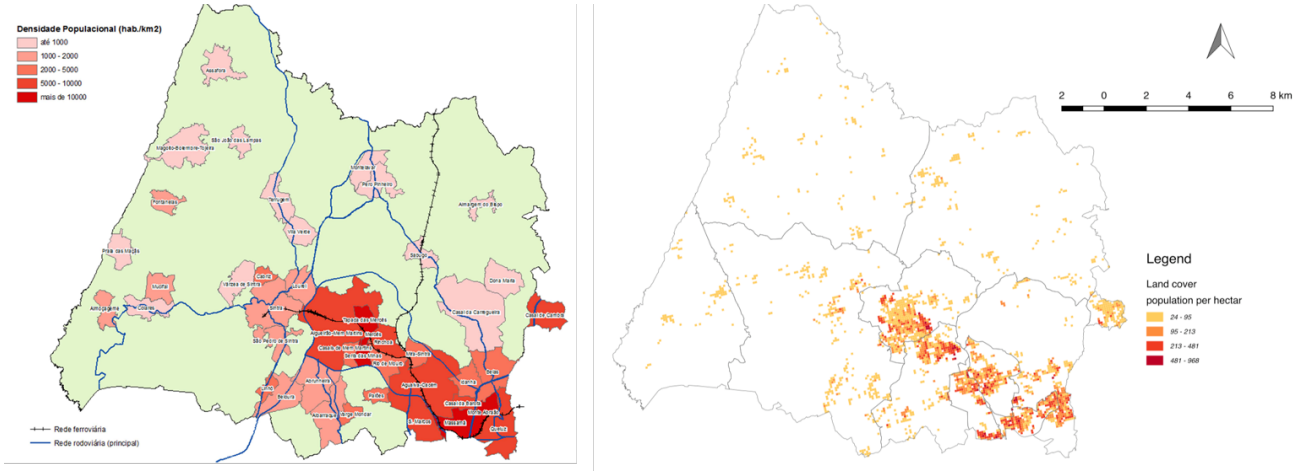

Figure 84 – Comparison of the map of population density by CM Sintra and the map of Population density reported on the custom 100x100m grid

The mapping performed using our model and reported onto the custom grid 100x100m confirms this populational behaviour, with the only difference of having a different approach in terms of value breaks of the feature of population density.

While the population density per hectar displays a distribution clearly marked by the proliferation of residential centers along the railway line Lisbon-Sintra, the education levels show a different distribution. Regarding the level of education of its population, Sintra features a percentage of residents with a level of education corresponding to ISCED classes 5 to 8 unevenly distributed throughout its territory. Figure 68 shows how the more peripheric areas in the municipality are less likely to be inhabited by people with higher education levels.

A few locations stands out: one of them is the southern border of the municipality close to Queluz, there other one is Belas, characterized by a gated community built around a golf course, sporting higher levels of education than population density. On the other hand a location with high population density and low levels of education is the area of Casal de Cambra, where a former AUGI settlement transformed into a legal urbanized neighbourhood.

Another important trait of Sintra's population is the relative young age of its residents.

Regarding the age of its population, the Municipality of Sintra presents the most balanced pyramid of the regional context, in other words, in addition to surpassing the national and regional mean values, it generates conditions that are potentially very favorable to the maintenance of positive natural growth and balance of the population. This will allow the potential natural regeneration of the population, while safeguarding the impact of migratory flows, which are always fluctuating and highly conditioned by the economic and employment context.

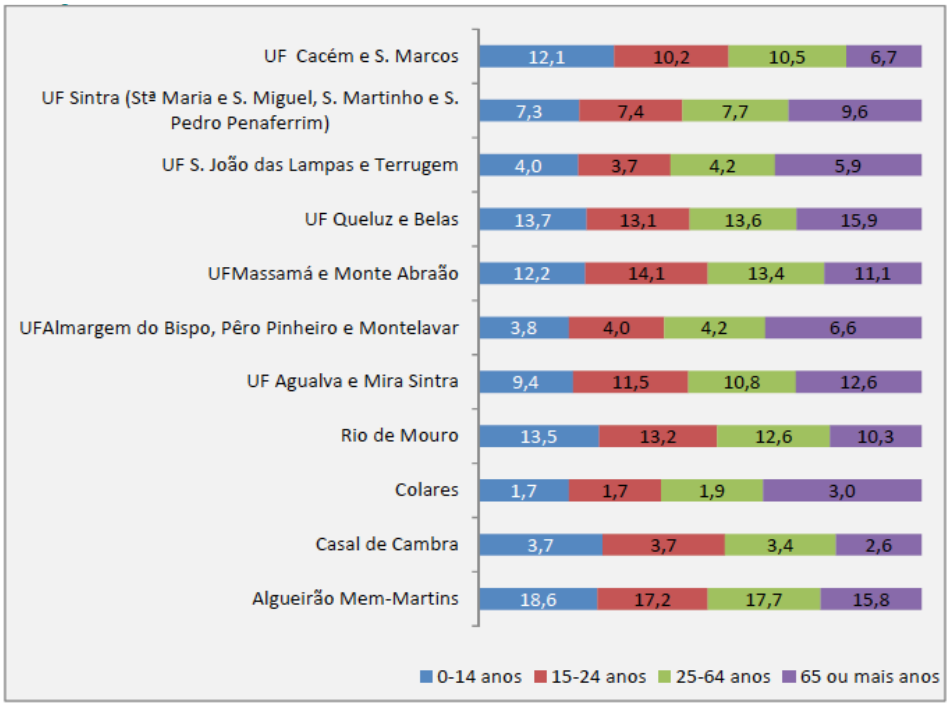

Figure 85 - Resident population by age groups divided by parish (source: CM Sintra)

It can be observed that the parishes with the highest number of resident population in the 0-14 age group are: Algueirão Mem-Martins (12381 residents), Belas and Queluz (9121 residents) and Rio de Mouro (8987 residents).

In the age group of 15-24 years, the parishes with the highest number of residents are: Algueirão Mem-Martins (7552 residents), Massamá and Monte Abraão (6177 residents) and Rio de Mouro (5813 residents). While in the 25-64 age group, Algueirão Mem-Martins (38179 residents) is the parish that has the largest number of resident population, followed by Belas and Queluz (29260 residents) and Massamá and Monte Abraham (28871 residents).

In regard to the resident population aged 65 and over is Belas and Queluz (8194 residents) that presents the largest number of resident under this age group, followed by the Algueirão Mem-Martins (8138 residents) and Agualva and Mira-Sintra (6504 residents).

In 2011, in the Municipality of Sintra, the population aged 0-14 represented 17.6% of the total resident population (it was 18.1% in 2001), in the 15-24 age group had a 2% loss

compared to 2001 (11.6% in 2011), while in the group aged 65 and over it grew by 3.4% compared to 2001 (13.7% in 2011).

In Sintra, in fact, the 0-19 age group represents the highest value of the North AML, while the age group above 65 years represents the lowest percentage in the same territorial context.

On the opposite side is the Municipality of Lisbon, which gathers the most unbalanced age pyramid of North AML, with the population above 65 years of age, which already surpasses that of the 0-19 age group.

In the figure below it is possible to see how the concentration of residents under 25 years old in unevenly distributed. While the most populated areas sport a high degree of residents under 25 years old, the most peripheric areas show very low values of residents under 25 years old.

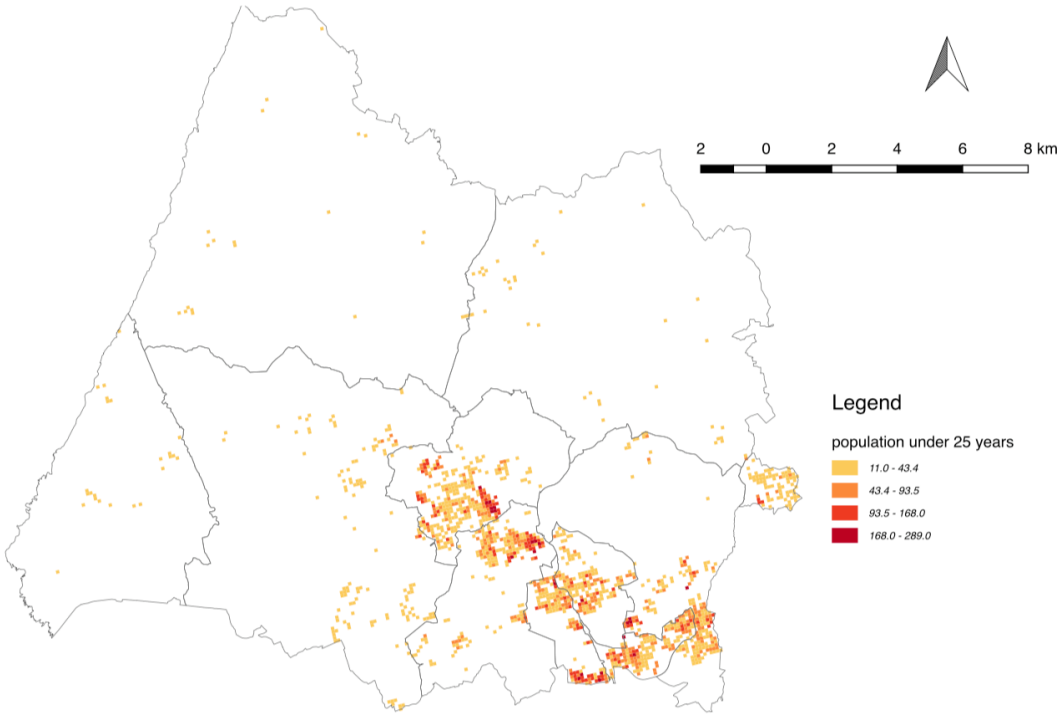

Figure 86 - Mapping of the distribution of the population under 25 years old

Figure 87 shows the different distributions between population under 25 years old and population with higher education levels (ISCED 5-8). While the young population is concentrated in locations like Tapada das Mercês, Mem Martins or Cacém, the population with higher education level show relatively high concentrations in Belas, in the centers of south-east border of the urban axis (like Queluz) and also in dispersed areas like Praia das Maçãs, Magoito, Mucifal among others.

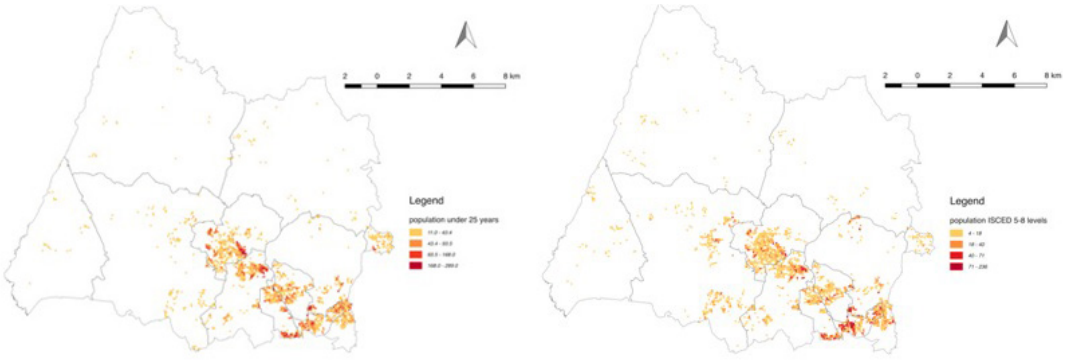

Figure 87 – Comparison of population under 25 years old and population with education level ISCED 5-8

Interestingly, we found a pretty strong correlation between the occurrence of companies and the values of resident population under 25 years old. This confirms that companies tend to localize in the most central places, leaving behind the peripheral location that tend to have higher aging indexes.

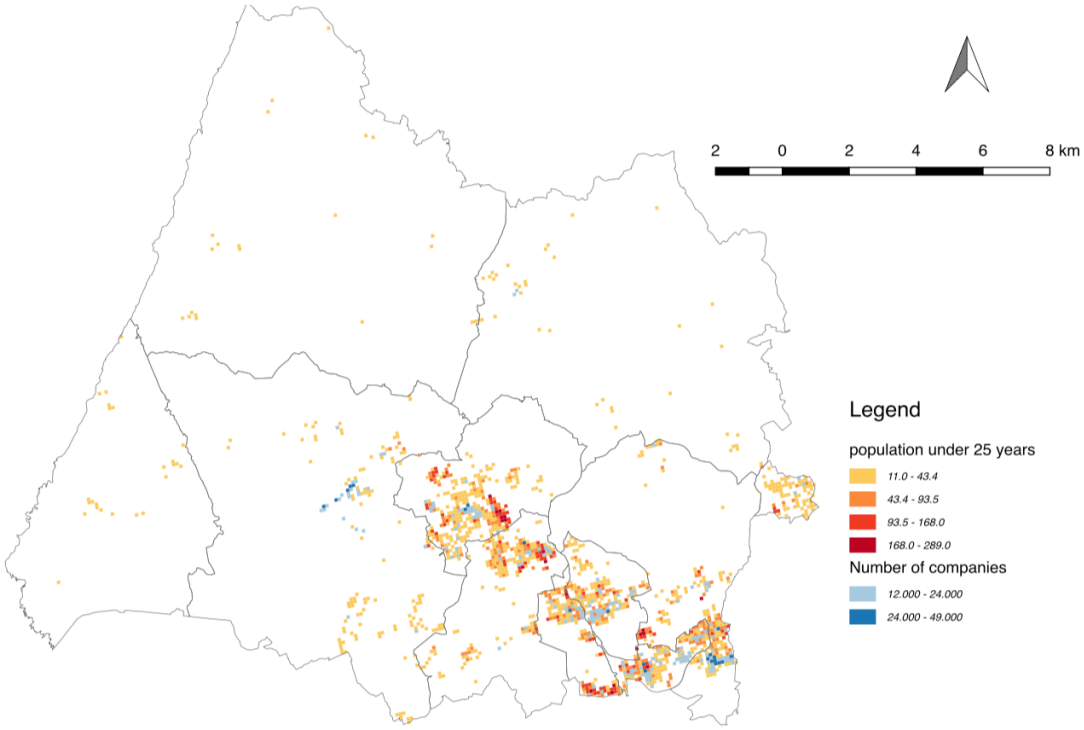

Figure 88 – Mapping comparing number of companies with population under 25 years old

8.1.4 Significant entrepreneurship milieu and economic dynamics

The municipality of Sintra is an important player in the Lisbon Metropolitan Area's economy, which represents about 37% of national GDP. In 2012, about 11.1% of the total companies of the AML were based in the municipality of Sintra.

Abrunheira, Albarraque and Algueirão Mem Martins are the locations that contain most of the industrial and entrepreneurial fabric of the municipality: about 38% of the total of the municipality. As we can see from the mapping below, the urban axis plays a central role here. But even outside the urban axis, there are some locations that thrive featuring a high relatively number of companies. It is the case of places like Montelavar or Pêro Pinheiro, but also Lourel, Terrugem, Vila Verde and Casal de Cambra.

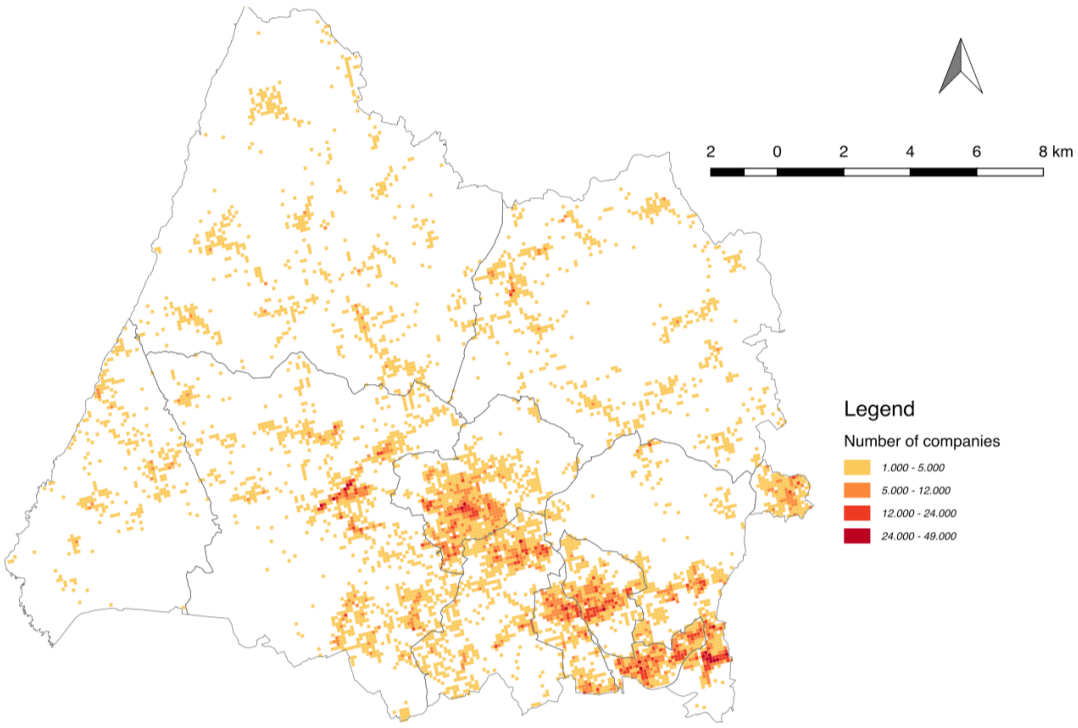

Figure 89 - Map of the distribution of companies over the municiapl district

The distribution of Sintra's companies reflects the dispersion of its territory. But even so there is a clear connection between the main road arteries and the localization of the main industrial districts of Sintra. As we can see from the mapping elaborated by the municipality of Sintra, we can find a urban core that developed along the railway line Lisbon-Sintra, then immediately adjacent to it we have the industrial clusters of São Marcos, Abrunheira and Beloura all place on the intersections with some of the main roads linking to the territory of Cascais on the south, then we have a big conglomeration of industrial clusters along the main axes connecting to Mafra's territory to the north –

part of this conglomerations are the industrial areas of Vila Verde, Terrugem, Pêro Pinheiro, Montelavar and Sabugo.

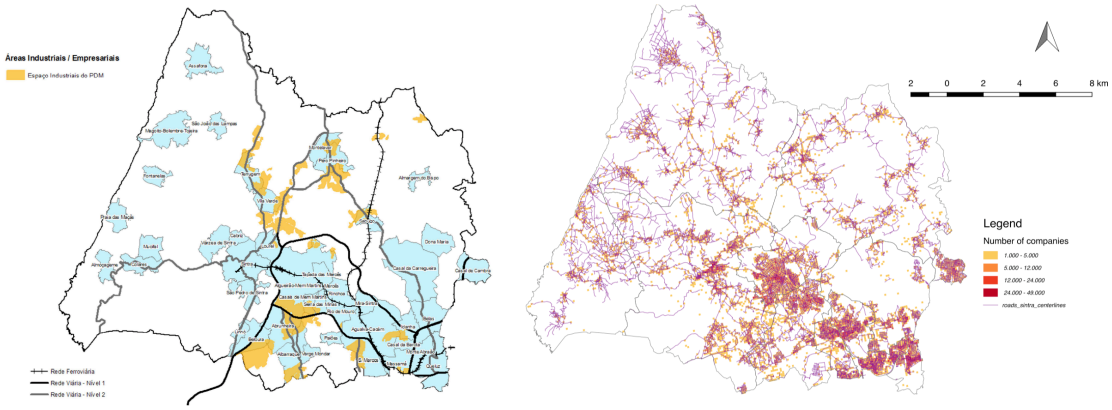

Figure 90 – Two different maps (one from CM Sintra, one by us) showing the relation between industrial areas and the main arteries of the road network

To go back to our results on the 100x100m grid, the mapping that we elaborated showed a clear tendency to territorial dispersion in the localization of companies: a kind of dispersion that was clearly going beyond the structuring of the territory operated by the main arteries. If the industrial districts are to be found along the main road arteries, the location of the sheer number of companies relies on a finer-grained network of small road the constitute the secondary structure of the territory. All this can be seen in the next figure.

8.1.5 Sintra's creative and cultural economy

Regarding the cultural and creative industries of Sintra we wanted to spatialize the relevance of such sectors over the territory, but also to understand its relation with the level of the education of the resident population. The filter applied to map culture-related businesses included all the activities falling within the categories of leisure and culture, arts and crafts, but also communication and marketing, IT, media and sports. Figure 53 illustrates this distribution.

While the mapping of the distribution of the cultural and creative activities of the municipal area showed similar dynamics as the ones of the overall distribution of companies throughout the municipal area but with a more intense concentration along the urban axis of Mira-Sintra, Algueirão-Mem-Martins, Queluz and Vila de Sintra, we started to look for connections with other indicators.

By comparing these locations with the distribution of the resident population with education levels ISCED 5-8 (Figure 91) it was possible to find a strong correlation. Such correlation doesn't imply that there is a cause-effect relation tough.

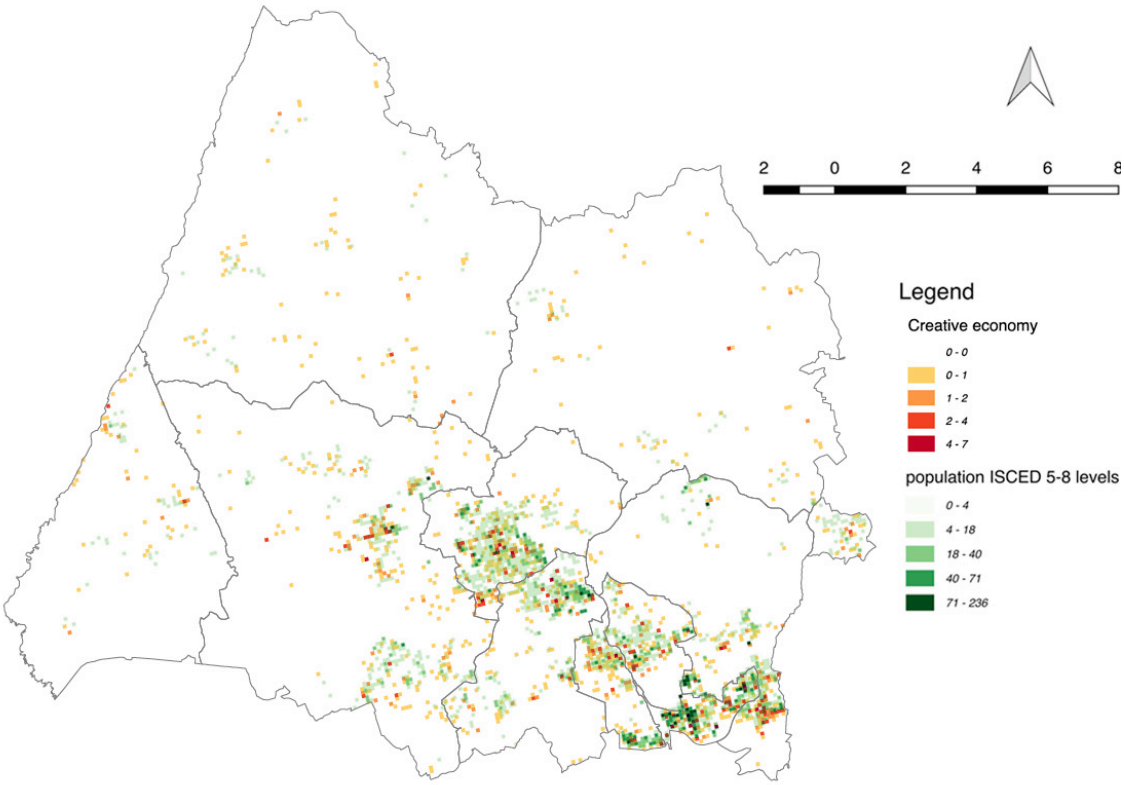

Figure 91 - Mapping of the relation between ISCED levels 5-8 of resident population and distribution of creative and cultural businesses

8.1.6 Public services and social support

We then looked at the supply of public equipment throughout the territory in a similar way as the one we presented for the spatialization of Sintra's cultural and creative industry. In Figure 54 we mapped the locations of those services such as kindergartens, schools, culture, leisure and sports activities to look for emerging patterns and overall distribution.

In the case of sport, education and cultural services however the concentration that we saw for the creative industry businesses is less exacerbated. The map in Figure 54 shows how less intense the concentration along the urban axis of Mira-Sintra, Algueirão-Mem-Martins, Queluz and Vila de Sintra is as compared with the spatial distribution of the creative industry businesses.

8.2 Weaknesses

8.2.1 Urban sprawl

When looking at the overall urban sprawl distribution over the territory of Sintra we can see that the issue of land consumption is a serious threat to Sintra's landscape. High rates of unregulated urban sprawl translated into a degradation of the environmental value forming a landscape that became more and more transgenic – not urban nor rural,

disseminated with productive facilities and big commercial surfaces all over without an overarching hierarchy in most cases.

Apart from the traditional nuclei of Vila de Sintra and urban axis, the rest of the territory is affected by phenomena of severe urban dispersion. This happens in many formerly purely rural areas (Almargem do Bispo, Montelavar and São João das Lampas).

It is interesting to see how almost the whole municipal area presents scattered points of high values of dispersion index (Figure 55).

In Figure 92 is represented a comparison between two way of calculating urban dispersion: one is the map of the compacity index based on the BGRI of INE elaborated by the municipality of Sintra, the other is the dispersion index elaborated by us based on the reporting grid 100x100m. By comparing the two we can see that a big part of the dispersion takes places in the rural land, fact that it is not captured by the compacity index at BGRI level.

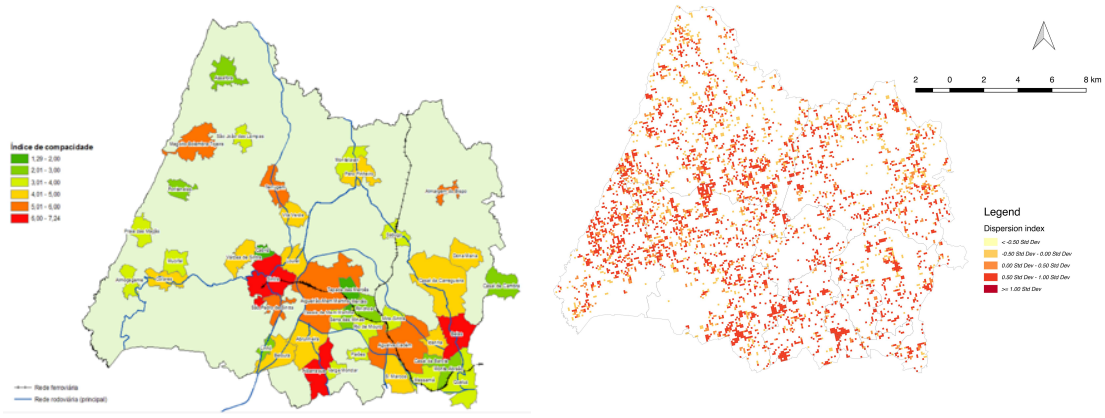

Figure 92 - Comparison of Compacity Index by CM Sintra and Dispersion Index by us

Another interesting fact is seeing how the major of such urban dispersion concentrates at the margins of the principal road network structure, as such road network help catalizing urban conglomeration along its axes while the most dispersed urbanization has to be structured by mean of secondary road networks.

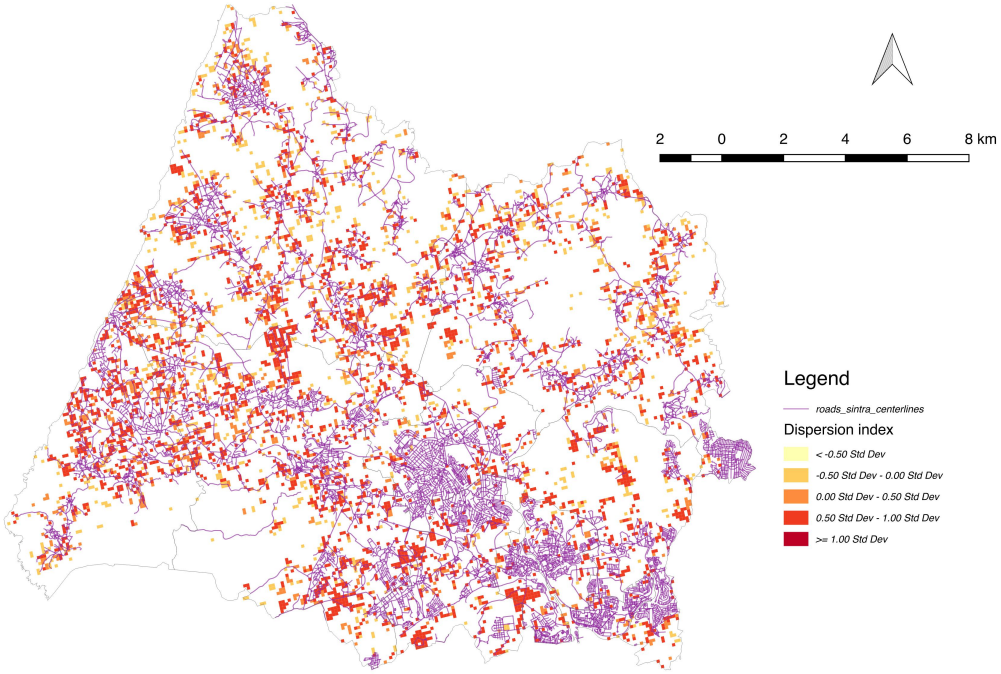

Figure 93 - Relation between urban dispersion and primary road network

8.2.2 Employment and qualification

Employment rates and overall qualification of the population are key elements for building a strong "human capital" that can translates into potential for territorial development and competitiveness. In this case, poorly qualified population translates into high unemployment rates. Also the progressively aging population (increasing aging rate and decreasing birth rate) contributes to deteriorate the human capital of Sintra. Aging population and poorly qualified population are two of the biggest threats to successful territorial development and economic growth.

Sintra, in fact, shows an uneven distribution in education levels as the most densely populated area (the urban axis Lisbon-Sintra) displays lower percentages of population with higher education levels. At the same time, in this area there is a relatively large part of the population facing the issue of finding it difficult to integrate itself in the job market. As we can see from the two following mappings, the levels of education and the population unemployed are not symmetrically spread over the municipal territory. It does not surprise the fact that the share of population with higher education levels is highly concentrated in rather specific locations, usually were more luxury real estate is located. This is the case of the area of Belas Golf club, Beloura, Villa de Sintra and the areas between Colares and Praia das Maçãs.

The unemployment rate shows a wider dispersion, though. In truth, with an unemployment rate higher than the average of the AML and the country suffers from issues of human capital development because of relatively poor figures or uneven distribution in those two indicators – education levels and unemployment.

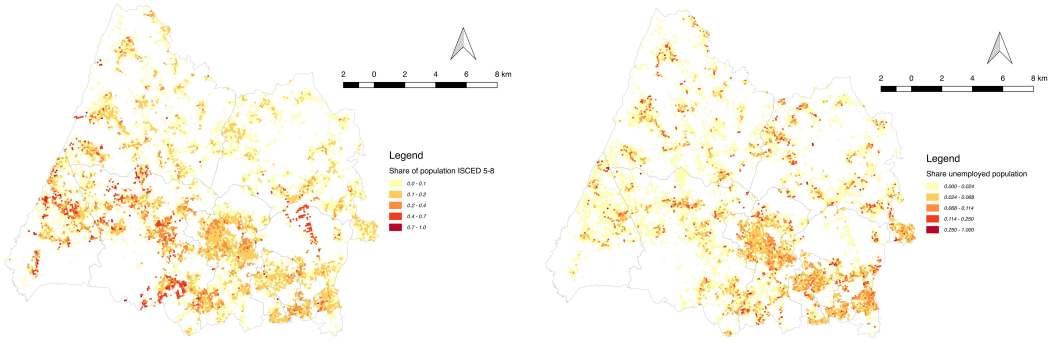

Figure 94 – Comparison with map of the share of resident population with education level ISCED 5-8 and map of the share of resident population unemployed

Moreover, the issue of an aging population may exacerbates the difficulties in strengthening the human capital development of the municipal territory. As we can see from the two figures below, Sintra's aging map shows a different behaviour as related to the population density. The distribution of aging has a character of higher dispersion than the population density, which concentrates on the urban axis Lisbon-Sintra (Figure 95). When it comes to the aging index such concentration is no longer valid and, as we can see from this mapping, the urban dispersion coincides also with an aging index dispersion.

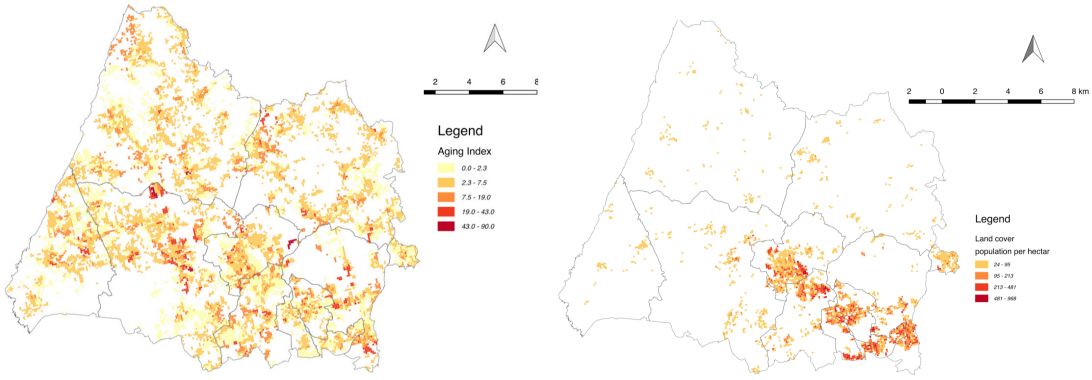

Figure 95 – Comparison with mapping of aging index and population density

8.2.3 Potential depletion of natural resources

When looking at the depletion of natural resource on our territory one the first assets that gets more easily consumed is soil. As we saw in the previous chapters, Europe is facing serious problems of urban sprawl and consequentely of soil consumption.

Portugal is not immune to this trend. In fact, most of the biggest conurbations of Portugal (the metropolitan areas of Lisbon and Oporto and the Algarve) display high rates of soil consumption. We already focused on the reasons why this happened, as well as on the legislative paradigm change that has been introduced in order to tackle this issue. We will concentrate here in presenting the mapping that resulted from our research and that can help to cast some light on the state of soil consumption in Sintra's territory.

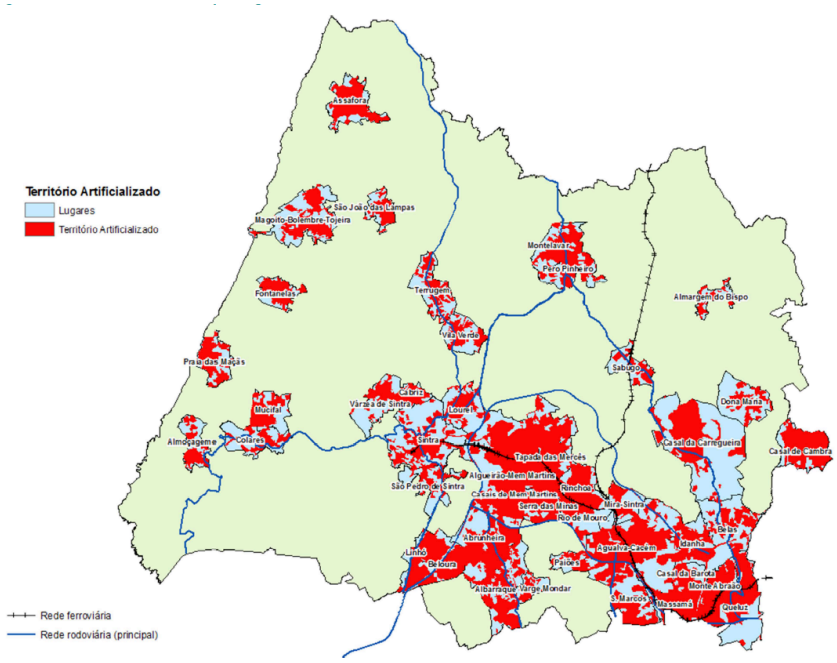

Figure 96 - Artificialized land map

While the map produced on this topic by the municipality of Sintra in the context of the latest PDM revision focuses on the mapping of the artificialized (sealed) soil for each of the places, "*lugares*" as they called them, of Sintra, we concentrated on the whole municipal territory.

By looking at two different density indicators such as GSI (Gross Space Index) and FSI (Floor Space Index) we demonstrated the asymmetry between building intensity and land coverage in Sintra's territory. The coverage map of GSI, in fact, many more high-value locations as the FSI. Places like Almoçageme, Mucifal, Pêro Pinheiro, Montelavar, but also Magoito, São João das Lampas, Casal de Cambra show much higher values of land coverage than of building intensity. Overall, when looking at the two maps of GSI and FSI in Figure 97, it is possible to see how construction (and subsequently urbanization) is very much more spread out than building intensity. While building intensity peaks only along the urban axis Lisbon-Sintra, the GSI shows different peaks in many more location on the territory returning an image of great urban dispersion and soil consumption.

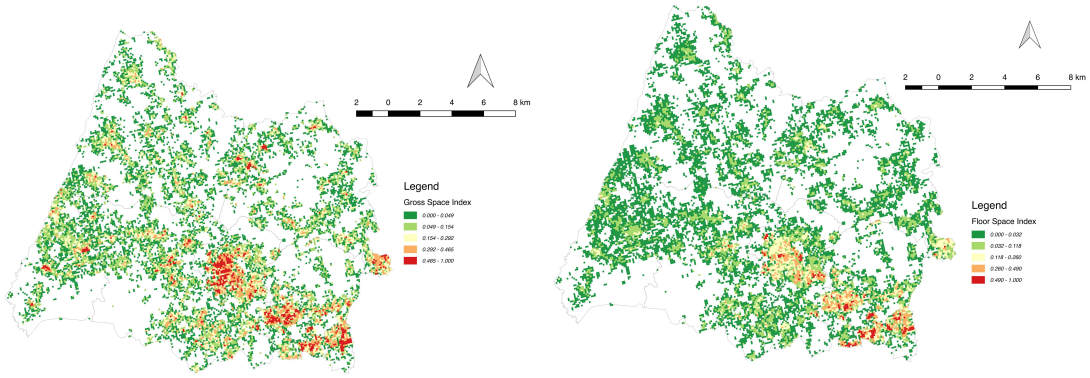

Figure 97 – Comparison of Gross Space Index and Floor Space Index mappings

Another potential issue for territorial sustainability that we highlighted in the SWOT analysis is the monofunctionality of certain areas when suburban modes of living imply a strong housing component and reduced supply of local trade and services (monofunctionality).

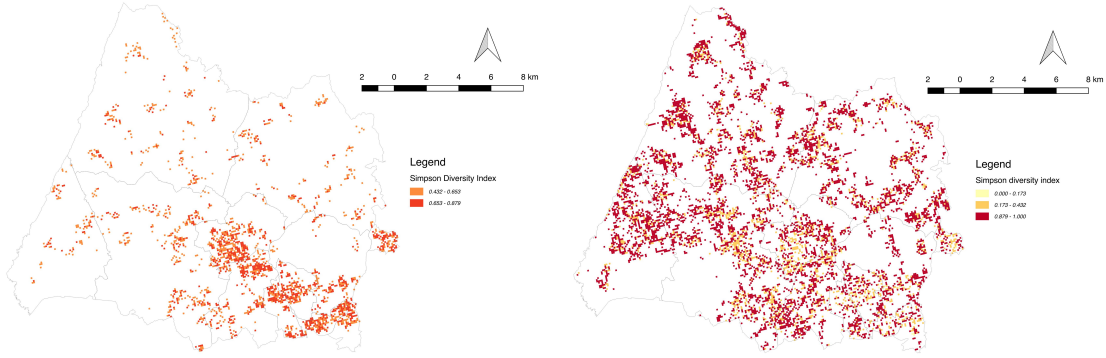

Figure 98 – Comparison of mapping of Diversity Index (mid-range values) with mapping of Diversity Index (low and high-range values)

In order to get a cleared view at this potential weakness of Sintra's system, we analysed the Simpson Index of Sintra's functions. Such index as we illustrated in the previous chapters highlights the locations where there is a higher diversity of functions: in our case diversity between residential units and economic sectors. As it turned out the urban axis is the area where most of the mid-range values of diversity are to be found, while both the low-range and high-range values are spread out over the whole municipal area.

Another issue that has been pointed out in the SWOT analysis in the poor connectivity between urban centralities. This is a particularly important weakness as it undermines the goal of Sintra's municipality of turning Sintra a more policentric territory. Such connectivity at municipal level (15km radius) is well expressed by Space Syntax's measure Choice. Choice measures how likely a street segment it is to be passed through on all shortest routes within a predetermined distance (radius) from each segment, in this case we selected 15km radius as a measure of car-oriented accessibility between different urban centers. This feature is highlighted in Figure 60.

8.3 Opportunities

8.3.1 Favorable context for increasing competitivity and development

Among the most relevant opportunities for Sintra as highlighted by the SWOT analysis performed in the context ot the PDM revision, the integration of Sintra in the Metropolitan Area of Lisbon and the proximity to the capital as well as to the important entrepreneurial cluster of Tagus Park. This set of localization advantages may contribute to boost the competitivity of Sintra translating into a competitive advantage both the in context of the AML and of the whole country. Figure 61 illustrates how Sintra's road network is integrated into the AML network system and how connected Sintra is to Lisbon. As a measure of integration we selected two indicators. As you can see in Figure 99, integration and choice show pretty different results: they show how the most integrated are is the south-east side of the urban-axis, while it also stresses how the majority of the in-between paths (the choice value) is represented by the IC19 and A16 roads. These two roads show high values in both choice and integration.

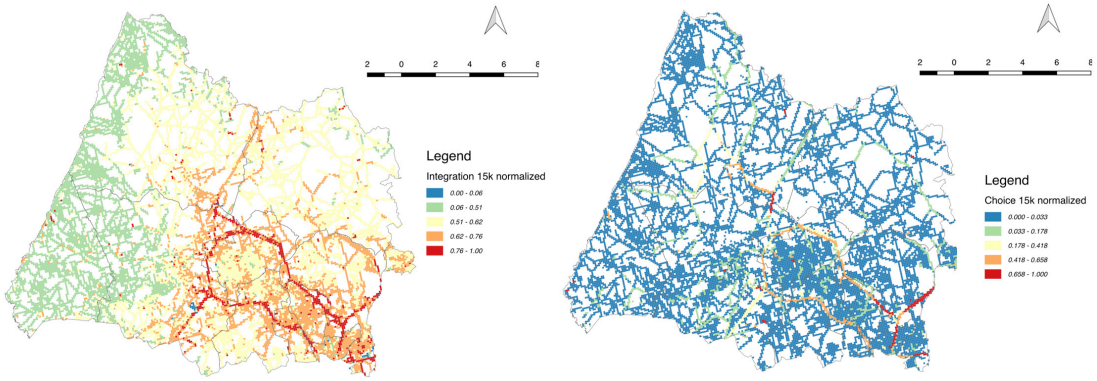

Figure 99 – Comparision of the Integration 15km with the Choice 15km maps

By looking at the distribution study of the two indicators, Integration 15km and Choice 15km, it is possible to notice the big difference in distribution pattern. While the results of the Integration are more evenly distributed, the results of the Choice show a more steep curve signalizing a much more unevenly distribution. While this behavior of these two indicators is normal, it is important to notice how positively integrated is a large part of Sintra's road network to the overall road network of the AML North. Also, an important factor is to see how the road segments that display high values of Choice are

surrounded by areas of high values of Integration indicator as well, making it a good mix for high accessibility and ultimately for potentially high urban liveliness.

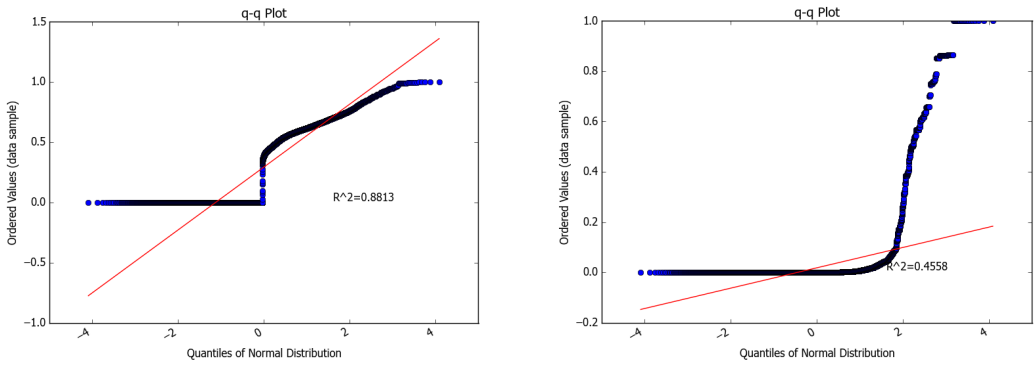

Figure 100 - Distribution study comparison: Integration 5km versus Choice 5km

8.4 Threats

8.4.1 Urban pressure

The SWOT analysis also pointed at the threat of urban pressure in areas that still preserve notable natural features such as coastal zones, nature parks, environmental and landscape sensitive areas. With the latest Census data available on this theme we made use of our model to highlight which are the area where the construction of new dwellings has been more intense during the last two measured decades, as you can see in Figure 62.

8.4.2 Worsening of social conditions in the country

In the threats section of the SWOT analysis, the only item for which we had sufficient data to make an in-depth analysis has been the aging rate. As the SWOT analysis points out the high aging rate and low birth rate at national levels will cause in the near future consequences on the generation renewal deficit. This is a threat also for Sintra that, although has been traditionally the municipality with the lowest aging index of the whole AML North, is now rapidly evolving towards an increasingly aging population. Beside looking at this fact, it is important to spatialize such phenomenon and to be able to look at what are the locations in the municipal territory were the aging population represents the highest percentages of the population. In Figure 101, we present a comparison between a map elaborated on the basis of the Census data, disaggregated to match the resolution of our customs 100x100m grid that shows the distribution of the aging of the population over the territory and a map of the aging index produced by the municipality.

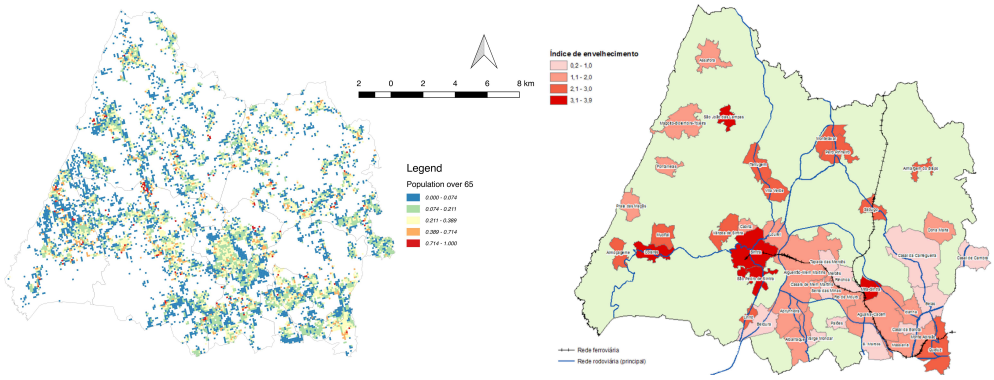

Figure 101 – Mapping of the population over 65 years old (normalized value)

It is interesting to see how the higher resolution of the reporting grid 100x100m allows for a much more refinied analysis of the distribution of the features over the territory. Also, one can expect the population over 65 is more concentrated on peripheric centers rather than in the big conglomerates of the urban axis. It is interesting to see what separates those peripheric centers or dispersed areas that have high values in population over 65 from the ones that have low values: one thing seems to be the integration in the systems (see Figure 99).

9. DISCUSSING THE RESULTS OF THE TERRITORIAL PROFILING

We already saw how we employed the model conceived for this thesis for the spatialization of the SWOT analysis of the territory of Sintra performed for the last revision of the PDM. We will present here another application of the model that constitute a procedure capable of guiding through the process of evaluating and assess development scenarios for a specific region.

The aforementioned application returned a series of results that will be presented here, with mappings based on the custom grid 100x100m proposed in this work.

We will compare the results of the territorial profiling, comparing them with the scenarios proposed by the municipality of Sintra for the future of their territory in the latest revision of the PDM.

We will start by comparing the results obtained by the application of the proposed territorial profiling with the Territorial Development Model of the PDM of Sintra in what concerns each of the scenarios analysed in the present work.

9.1 Comparing results with Sintra's PDM

The Territorial Development Model (MDT) of Sintra comprises a set of strategies with territorial expression that can be translated into a vision, developed in a few strategic axes and objectives, that illustrates the path proposed to achieve a few desirable future scenarios.

The main vision for Sintra, expressed in the Territorial Development Model, is "Achieving an orderly, harmonious and diversified territory that promotes economic development from an integrated perspective - population, economy and environment - and the enhancement of the spaces that are part of it by reinforcing their identity and improving the quality of life of the populations." ("Modelo de Desenvolvimento Territorial aprovado por maioria na 3º Sessão Ordinária da Assembleia Municipal," n.d., p. 15)

In order to test a few hypothesis related to the specialization of parts of the territory and the challenge of building the foundations of the future of Sintra, we employed our

model to calculate and visualize a number of territorial profiles that could express the vocation of the place on one hand and match with the goal of a more polycentric and specialized territory, as expressed in the latest PDM revision.

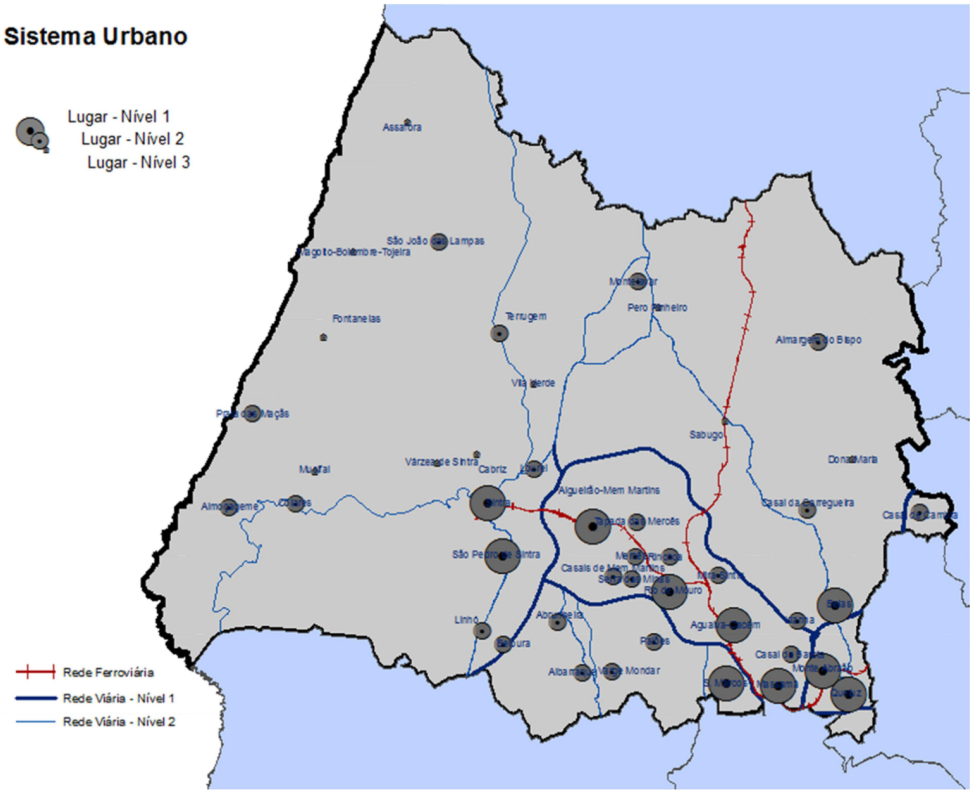

Figure 102 - Sintra's urban system as proposed in the latest revision of its PDM

One of the main aims of the Territorial Development Model proposed by the municipality of Sintra has been the creation of conditions for the reinforcement of the centralities of those place that already play a central role in the territorial system. Such reinforcement should be achieved through the diversification of uses (combating the residential mono-functionality) and the requalification of the central urban spaces.

In the next paragraphs we will explore the potentials and the vocations of each individual location within Sintra's territory, aiming at assessing the correspondence of the results of our model with the Territorial Development Model presented by the municipality.

9.1.1 Lively Urban Centers: results discussion

The urban locations identified in the Territorial Development Model of the PDM of Sintra as nuclei of Level 1 in the hierarchy of the urban system, correspond to the nuclei featuring the strongest centralities. In other words, these are the places that play the most central role in Sintra's territorial system.

What we want to check here is if such locations are also the places where a more lively urban center – as defined by our territorial profile – has been found. This would allow us to establish a link between the centrality of a location in the territorial system and an array of features (whether morphological, syntactical or populational) that characterize *de facto* the places that ranked the highest in the territorial system hierarchy.

The map in Figure 102, produced by the Municipality of Sintra, shows the hierarchy of places as calculated by the Municipality of Sintra in the context of the latest revision of the PDM.

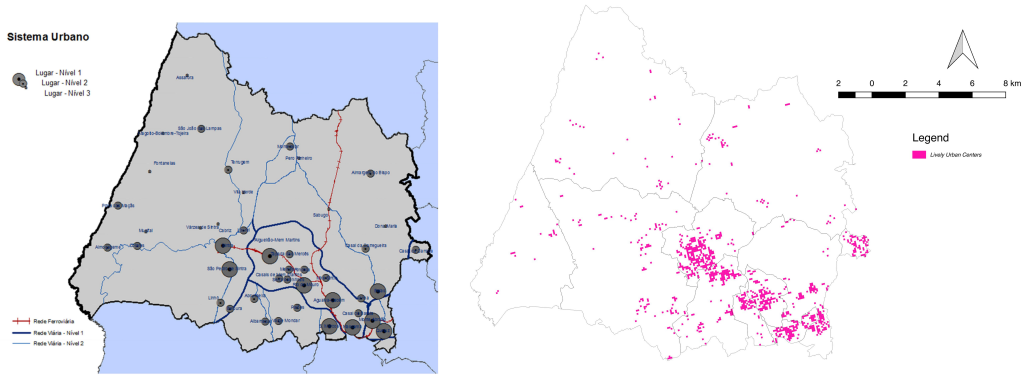

Figure 103 – Comparison of the Urban System proposed in the PDM of Sintra and the "Lively Urban Centers" mapping elaborated by us

From the comparison presented in Figure 103, between the mapping of the Urban Sytem as proposed by the Municipality of Sintra and the mapping of the Lively Urban Centers as elaborated by us, it is possible to see how the major nuclei of urban axis Lisbon-Sintra, that appear in the urban system of Sintra also appear in the lively urban centers map. It is clearly visible how the axis Sintra-Lisboa is the one that attracts the biggest number of centralities – i.e. lively urban centers, as translated into the terminology applied in this work.

These locations are the oldest urbanized nuclei of the urban axis that rose along the the railway line Sintra-Lisboa. The urban axis is the area that showed a higher concentration of locations falling under the profile "Lively Urban Center". Those locations are mainly present in Mira-Sintra, Algueirão-Mem-Martins and Queluz.

From our representation it is possible to see how the nuclei of Sintra, São Pedro, Agualva-Cacém, Mira-Sintra, São Marcos and Tapada da Merces are practically one single cluster with a strong centrality, featuring many cells of Lively Urban character.

After those centers, Massamá, Monte Abraão, Mem Martins, Rio de Mouro, Queluz also appeared to establish (weaker) centralities.

But there are also other locations labelled as lively urban centres that are totally detached from those nuclei. We tried to understand if there was a consistent pattern underlying the distribution of those places labelled as lively urban centers and we found out that they mostly coincide with the urban centers already established before 1970

(Figure 104). Such legacy seem to explain very precisely the actual distribution of lively urban centers nowadays. In this category fall places like Vila de Sintra, Mucifal, Almoçageme, Fontanelas, Linhó, Maceira, Montelavar, Pêro Pinheiro, Vila Verde, Dona Maria. Interestingly Casal de Cambras is also highlighted in the mapping as an hotspot Lively Urban character, probably due to the proximity of Odivelas and the number of economic activities it hosts.

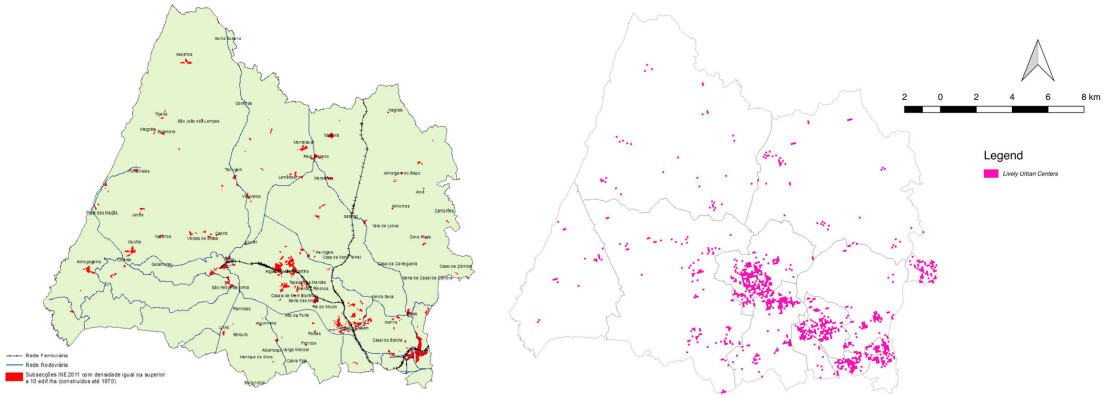

Figure 104 – Comparison between statistical subsections with density equal or higher than 10buildings/ha. built until 1970 (Source: INE, Census 2011) and lively urban centers distribution

9.1.2 Not Lively Urban Center: results discussion

On the other hand the mapping of the Not Lively Urban Centers shows locations in the territory that are – contrary to the previous analysis – not as lively. These are places that, although constituting urban centers, don't display the same range of positive urban features compared with the Lively Urban Centers.

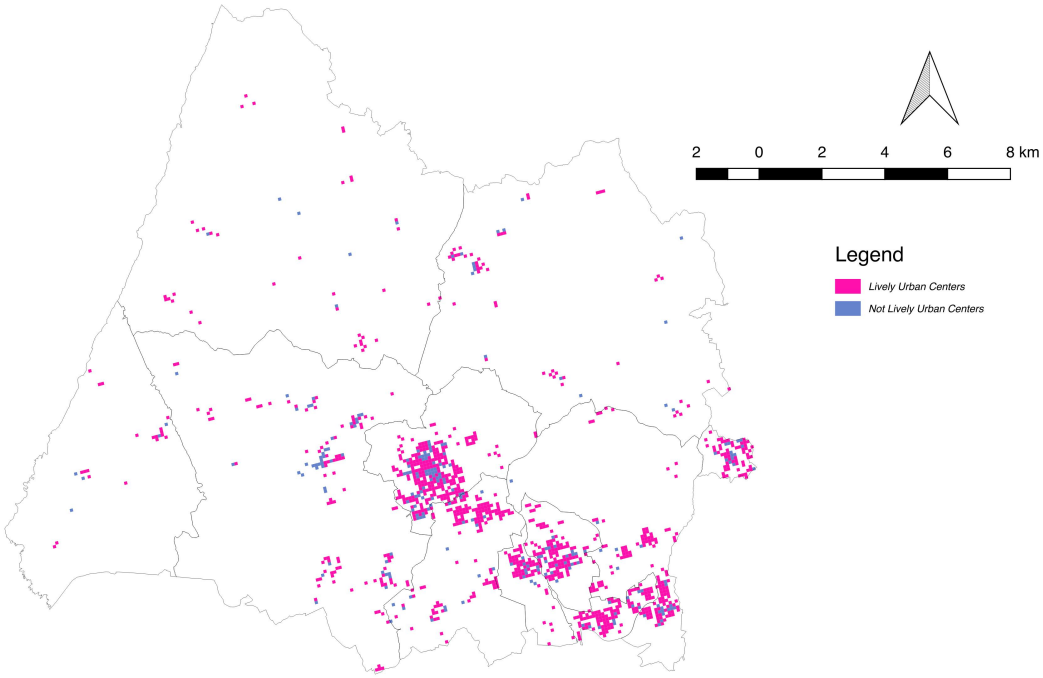

Figure 105 – Lively Urban Centers versus Not Lively Urban Centers

From the comparison, between the mapping of the Urban System of Sintra of Figure 102 proposed by the Municipality of Sintra and the Not Lively Urban Centers mapping that we proposed, we can deduce that those locations that are highlighted by our model as Not Lively Urban Centers are generally concentrated in the urban axis but are more likely to be found in the areas that are marked in the Urban System mapping of Sintra as Level 2 nuclei rather than in the ones marked at Level 1 nuclei. This is the case of Casais de Mem Martins, Tapada da Merces, Serra das Minas that are highlighted by the proposed mapping almost as a single cluster.

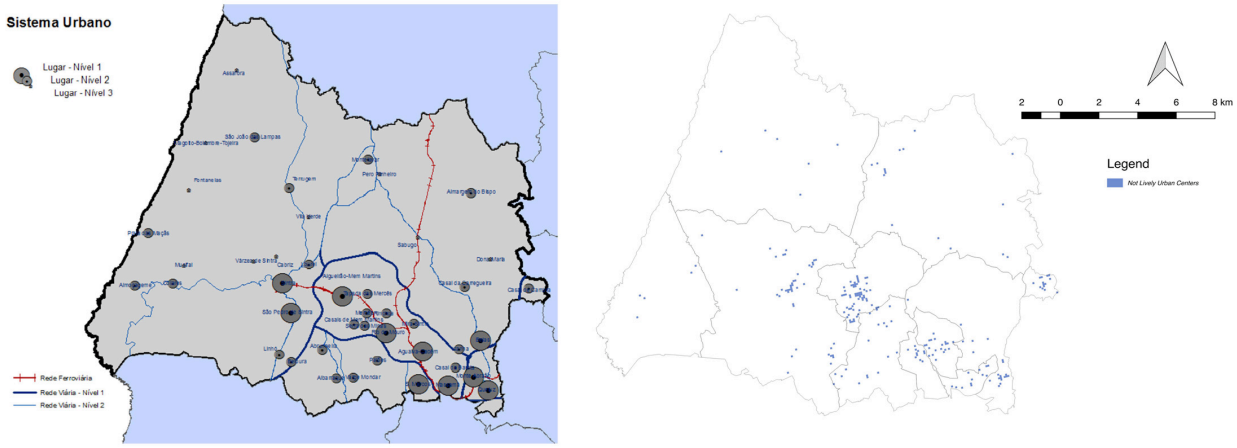

Figure 106 – Comparison between Sintra's Urban System (Souce: CM Sintra) and Not Lively Urban Centers distribution

Alternatively, some locations in the grid featuring a Not Lively Urban Center are also located around Level 1 nuclei, creating a surrounding cluster of lower values of "liveliness". This is the case of some locations in the town of Sintra and a few scattered locations between Massamá, São Marcos, Algualva-Cacém, Belas and Monte Abrão.

9.1.3 Lively Dispersed Areas: results discussion

The Lively Dispersed Areas are locations where, even if the urban density is low and the urban fabric is fragmented and dispersed, we still found traits associated with lively urbanity. Although sounding like an oxymoron, these are some of the locations that caught more our attention, as they seemed to be some kind of spots of "urbanity" in an otherwise uncharacterized, dispersed territory. In our understanding, these are the location that justify the most an investment in re-urbanization. In this areas, in fact, a process re-urbanization would more surely give positive social and economical results, as the location is already showing good performances in urban life even being morphologically still not dense enough to be considered a urban center.

Regarding their distribution over the territory, it seems that the locations of what we called Lively Dispersed Areas are often to be found in close proximity with the primary roads that structure the territory of Sintra. This may have an historical explanation: these roads follow the paths that are the most ancient in Sintra, so along these roads many urban clusters arose. Outside of such urban cluster, however, in territories that are currently dispersed, there are traits of lively urbanity. In Figure 107 we illustrate the relation between the primary road network and those lively dispersed areas.

But while these Lively Dispersed Areas are close to the primary roads, they are away from the residential streets of the urban clusters, meaning that are location outside of the urban nuclei, located in dispersed but lively areas. This is the case of many locations that are close of traditional rural urban nuclei but are outside of their residential core. As one can see from Figure 107 such locations of the Lively Dispersed Areas are mostly to be found in the rural north and residential west parts of the municipal territory. Note also how they relate to the primary road network: they are close to it but almost never in very close proximity.

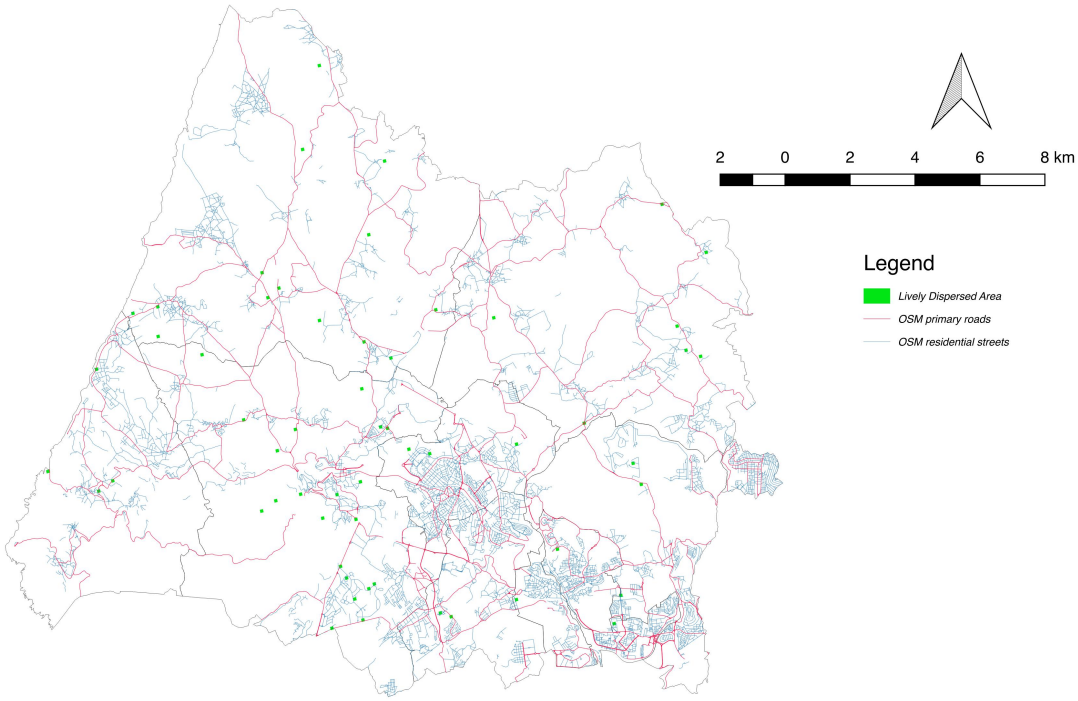

Figure 107 – Relationship between primary roads, residential streets and Lively Dispersed Areas

9.1.4 Not Lively Dispersed Areas: results discussion

Contrary to the Lively Dispersed Areas, the Not Lively Dispersed Areas are places where we don't find traits associated with lively urbanity: the indicators associated with urban "liveliness" are low and the urban fabric is fragmented and dispersed, In our opinion, these are the locations are not the best to pick in an effort of re-urbanization. In fact, a process re-urbanization here would not surely give positive results. For a variety of reasons, these locations display poor performances in "urbanity" indicator and therefore then to be less lively at other locations. One explanation is that these locations, by being both dispersed and monofunctional, fail to gather the essential component of a lively urban fabric.

By looking at Figure 108 we can see how the Not Lively Dispersed locations are mostly places in areas with difficult accessibility, either because they are remote or because they are located at the periphery of minor urban nuclei from where they get access almost exclusively through cul-de-sac roads.

This somehow explains how the "liveliness" of a specific location in dispersed areas is linked to the road network accessibility. Therefore if one would like to increase the urban "liveliness" of the specific location should first and foremost concentrate on accessibility.

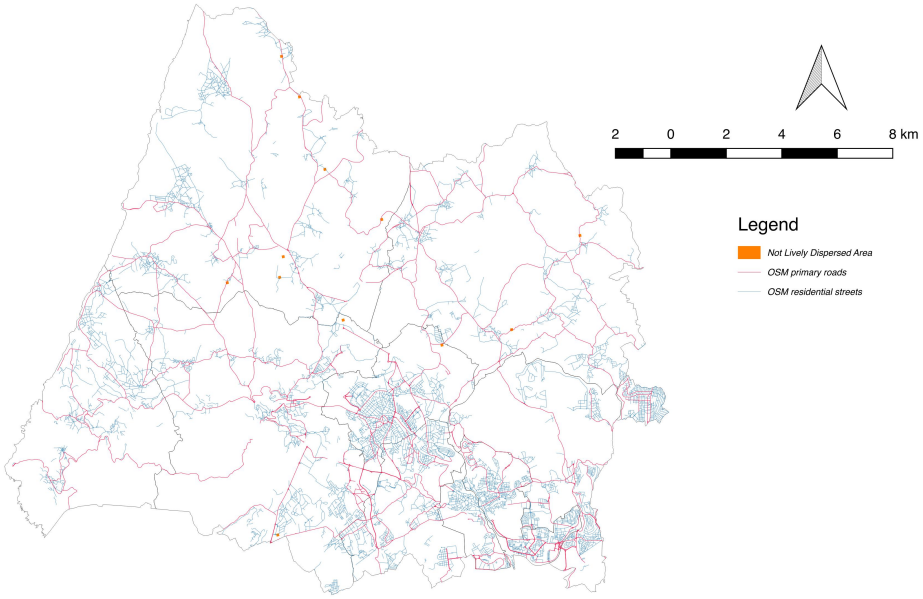

Figure 108 - Mapping comparing the localization of Not Lively Dispersed Area with primary roads

We find such territorial profiles of Not Lively Dispersed Areas close to Aldeia Galega, Alpolentim, Ral where the Choice values of radius 5km are pretty high, denoting that the place has a high change on being on the most frequented paths of Sintra's road network, and then also between Covas de Ferro and Albogas, Alvarinhos and Santa Susana, Sabugo and Almornos, locations that are much more remote and difficult to access. This dual behaviour of the distribution of Not Lively Dispersed Areas made us think that a location by either be too much of a transit-oriented place, i.e. where people pass-by instead of living in, either too isolated and difficult to reach, falling more easily under the label Not Lively Dispersed Areas.

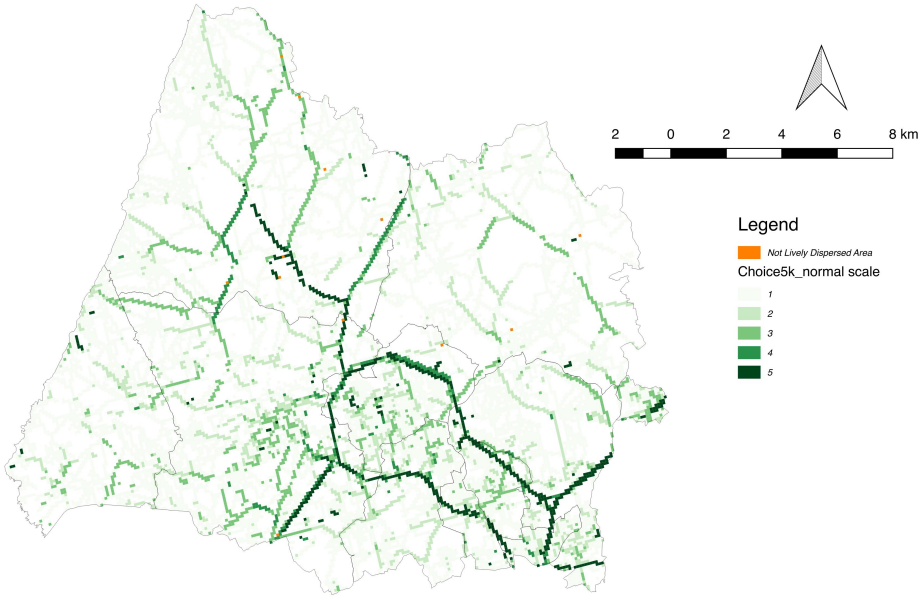

Figure 109 - Relation between Not Lively Dispersed Areas and Choice 5km radius

Such in-betweeness condition of being located close to road segments that are to be passed through on the shortest routes within a specific distance (radius), is perfectly captured by the Choice indicator coming from Space Syntax theory, illustrated here in Figure 110. As you can see the Not Lively Dispersed locations are to be found both in the darker colored segments, with higher values of Choice, or in very remote areas of the municipal territory with lower values of Choice.

9.1.5 Dispersed Areas with Potential to Become Place or Node

Regarding the dispersed territory we wanted to concentrate our attention on a few more territorial profiles. That is because it is this kind of territory – the extensive, dispersed territory – the one that interests us the most, being the one where interventions of re-densification and re-urbanization are needed the most. For this reason we included a few reflections here on those location that due to their inherit vocation are better suited to envolve into a transportation node or into a living place.

As we can see from Figure 110 the distribution of those places whose territorial profile falls under the category of Dispersed Area with potential to become Place or Node is different. Being the two kind of profiles of dispersed nature, they both are located outside the infrastructured urban cores (as highlighted by the presence of residential streets). But while the locations with potential to become a Place show a scattered distribution, the locations with potential to become a Node coincide almost completely with road segments with maximum Choice 5km radius, proving their nature of being highly connected locations in the territorial network.

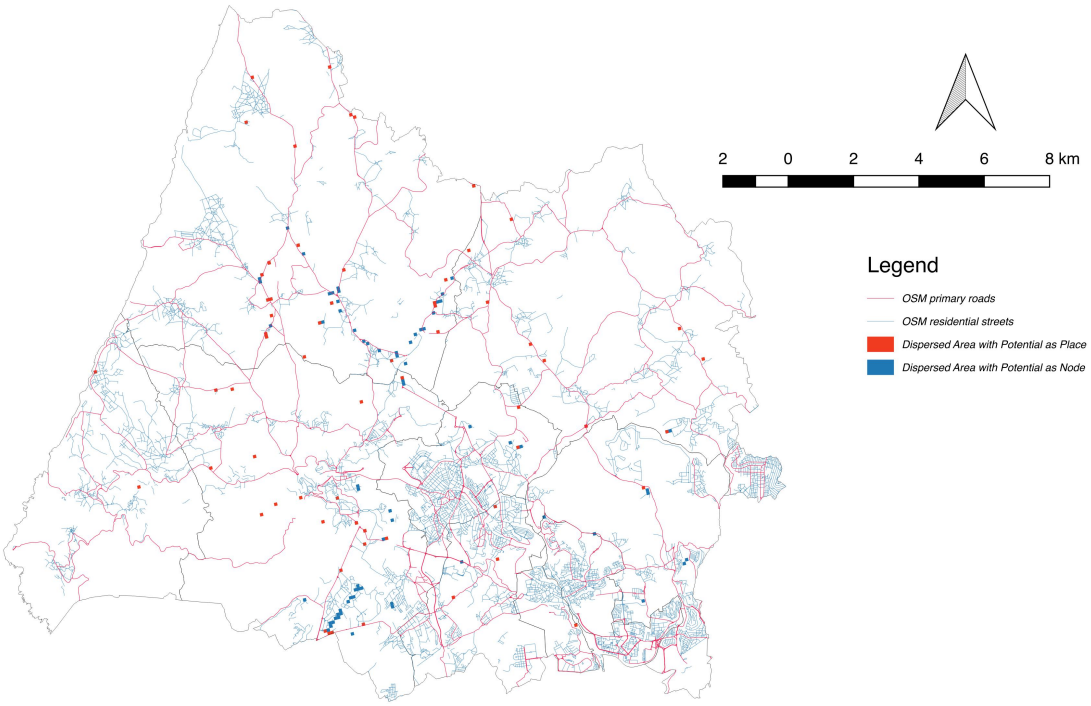

Figure 110 – Comparison of Dispersed Areas with Potential as Place or as Node

9.2 Re-urbanization potential

After having analyzed all the territorial profiles presented in the previous sections of this chapter, we can draw some conclusion on the overall territorial dynamics that emerged from this study. This is an important point because, above all, it responds to the main challenge of this thesis: the re-urbanization of the territories of dispersion.

As densification appears to have stabilized in Sintra, with the urban corridor developing along the IC19 and the Villa de Sintra and delimited to the north by the A16, we see an opportunity to contain the expansion and dispersion. In this respect the new revision of the PDM of Sintra, by drastically reducing the percentage of land categorized as "urban", dropping it from 32% of the total municipal area to 26%, gives a clear sign that one the main strategic goals for Sintra in actually the containment of urban perimeters, requalification of those nuclei that are already completely urban and the containment of territorial dispersion. To do that, actions of urbanization regeneration that will focus on the rehabilitation of the urban nuclei on the axis Lisbon-Sintra built during 1960-70 are needed as well as the consolidation / re-urbanization of the scattered built-up areas spread through the whole municipal area.

On the side of the extensive dispersed territories, as we can see from Figure 111, the two territorial profiles of the Lively Dispersed Areas (LDA) and the Dispersed Areas with Potential to Become a Place (DAPP), although being scattered by nature, show in a slightly higher concentration around a few locations. Such locations are:

- The area around Arneiro dos Marinheiros, Aldeia Galega, Terrugem, Chilreira featuring a combination of the two profiles
- The area around Ral, Vila Verde, Campo Raso and Lourel featuring a predominance of Lively Dispersed Areas
- The area of the stone extraction and transformation of Montelavar, Pêro Pinheiro and Armes with a predominant Dispersed Areas with Potential to Become a Place profile
- The area of Assafora, Santa Suzana, Areias and Alvarinhos featuring a predominance of Lively Dispersed Areas
- Aruil all characterized by Dispersed Areas with Potential to Become a Place locations
- Almoçageme also characterized by Dispersed Areas with Potential to Become a Place locations
- A few scattered locations concentrated around Beloura on one side and São Pedro de Sintra, Ranholas and the foothills of Serra de Sintra on the fringe with the Villa featuring a predominance of Lively Dispersed Areas.

It is important to point out at the differences between these two types of profile and what they really signify. While the locations characterized by the profile Lively Dispersed Areas display already rather significative features of urbanity, the Dispersed Areas with Potential to Become a Place highlight places with a certain potential to urban intensification or re-urbanization. So, one is more indicative of a present feature while the other is more focused on highlighting potential for densification.

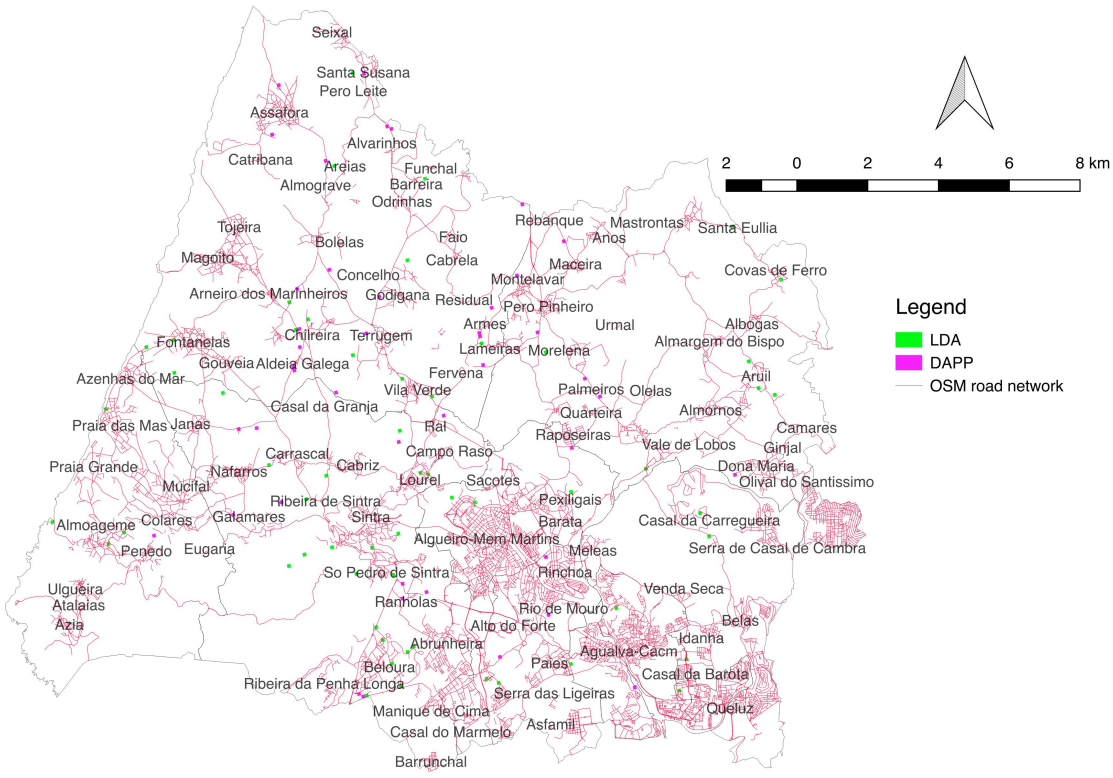

Figure 111 - Comparison with Dispersed Areas di Potential as Place and Lively Dispersed Areas

In this respect, such kind of analyses constitute the ultimate core of this work that aims at pointing out at novel analytical approaches and operative paradigms for the re-urbanization of dispersed territories in a context, like the current one in Portugal, where the primary concern for planners and stakeholder should be operations of urban acupuncture (Hoogduyn, 2014; Houghton, Foth, & Miller, 2015; Lerner, 2014) capable of enhancing re-urbanization and boost over urbanity in low-dense dispersed territories.

What we illustrated with our work is that these dispersed built-up areas, despite all "suffering" from scattered urbanization, are anything but homogeneous. Even in the context of urban sprawl, it is possible to find areas / places whose characteristics (either because of their location and integration into the network, or because of a greater concentration or diversification of activities and people, or because of some another factor) are indicative of a greater potential for re-urbanization and densification processes. That is, in addition to those central urban nuclei of the urban corridor, which are clearly urban and already display high compactness and urbanity characteristics, there are scattered areas more valid than others to be oriented to welcome consolidation and re-urbanization in the future.

10. CONCLUSIONS

This work set out to propose a viable methodological and conceptual framework capable in guiding in the decision-making process of developing and grounding a territorial development plan for extensive dispersed territories. This work, by selecting the municipality of Sintra as case study, ultimately served as a pilot test to prove the validity of the concepts and the operability of the methodological framework.

Such objective derived from the acknowledgment of a few gaps in the current planning practice:

- the lack of holistic approach to territorial analyses and the methodological and analytical fragmentation of the discipline of urban and regional planning. We started this work by asserting that the main factor hindering the full understanding of territorial systems is the methodological and analytical fragmentation of the planning discipline. With the present model we wanted to contribute to the testing of novel integrated multidisciplinary approaches to municipal and supra-municipal planning. This unifying endeavor was also one of the drivers of this work.
- Another issue that we recognized in the current planning practice is the extensive use of generic recommendations and strategic goals that most of the times fail to develop a territorial and spatial expression. The concept of territorial capital and the holistic approach to territorial analysis used in this study were proposed as means for dealing with the translation of abstract strategic guidelines to grounded territorial plans and policies. The underlying concept was to foster endogenous territorial development and to allow for a more rational use of economic and land resources by setting a framework of data-driven territorial analyses that would allow for more informed decisions in the context of regional and municipals masterplans processes.

This thesis presented a theoretical and operative approach for territorial planning involving conceptual and computational tools that are capable to lead to a correct analysis of the implications of planning proposal to the territorial capital of the analysed region.

One of the most central research question, in this sense, was:

- how can we measure and spatialize the elements that concur to the definition of the territorial capital of a specific region in order to be able to embed those findings in a traditional regional planning process?

As a response to this question, our work developed a methodological approach that proved to be a valid decision-support system for traditional PDMs and regional planning, capable of embedding features relevant for territorial capital analyses and providing immediate feedback to territorial analyses and planning, customizable to the needs of the specific planning task.

One of the main objectives of this work was to prove the value of a data-driven spatial analysis model to be used in the different stages of conceiving, designing and monitoring a development plan for an extended area, whether it is a municipal plan or an supra-municipal plan. A data-driven approach was proposed in order to deal with the complexity of the task, in particular when a spatial analysis of multivariable processes is needed to comprehend how the territory behaves under specific circumstances and from different scenarios points of view. Such approach has been at the basis of the present work. The main idea being that of supporting the traditional production of masterplans and development strategies, by coupling such traditional production with a decision-support system.

This model must naturally be associated with what the structure of the territory and the urban context (with its network of urban areas and hierarchies of places with different valences, vocations and potentials) upon which the overall system is anchored. In the case of our work this role is played by the territorial development model formulated for the municipal territory of Sintra.

10.1 The two levels of understanding of this work

The present work can be interpreted and analysed under two different perspectives, depending by the goals, the focus and the background of the reader. Experts of different disciplines can find here inputs and insights about topics closely related to their field, but in particular urban planners and stakeholder on one side and urban geographer, urban researchers and GIS experts on the other can find this work of interest for them.

There are two levels of understanding of this work, indeed. One has to do with the creation and testing of a model of urban development in a perspective of selective densification / concentrated densification. The other is the operative view of the planning process, its mechanisms, tools and methodologies for which this thesis gives an instrumental contribution with the crafting of a methodology capable of guiding through the analyses and calculations needed to support the decision-making phases of a planning process.

The two main ideas of this thesis have been, in fact, to:

- First, provide a framework for the development of urban development models within a context of urban sprawl / extensive urbanization. Such framework has been conceived as the direct response to the latest legislative developments that happened in Portugal regarding the land use classification, the disappearance of the so-called “urbanizable areas” and shrinking urban perimeters;

- Secondly, in order to provide an operative toolkit for this issues, we also introduced a new level of territorial analysis capable of supporting the traditional planning practice by providing a more holistic overview of the territory at hand and generating more data-driven insights capable to encompass changes in contextual conditions of the territory and also to provide a stronger basis to allow for systemic thinking decisions in the planning process. In other words, we proposed a framework capable to support territorial planning as an holistic systemic thinking process, with a strong focus on extensive dispersed territories, rather than a top-down decision process.

10.2 The research questions revived

In order to wrap up the results and the contributions of the present work it is crucial to revive here the central research questions that this work aimed to answer. As the work presents two main levels of understanding, we will discuss the research questions under these two separate perspectives.

10.2.1 The perspective of the urban development model in a context of extensive urbanization

Under this perspective fall those research questions that we mentioned at the beginning of our work. Now with the experienced formed during the completion of this work, after having successfully translated into an operative workflow the concepts related to the calculation of the territorial capital and the re-urbanization of dispersed territories, we can answer to those questions:

- What are the elements that make a location thrive, making it suitable for economic investment, increase in livelihood and re-urbanization processes?

As the theory of territorial capital suggests, there are several elements that can concur in creating the hotbed needed to make a location thrive and be suitable for densification and economic investment. In our work we noted that one of the most important factors in this respect is the location advantage of that specific location. This factor alone however does not provide any guarantee for enhancing urbanity. Such characteristics are to be found in the economic ecosystem of the place (its capacity of attracting economic activities and the diversity of its land uses) and in demographics (such as its capacity to attract new residents).

- How can we contrast the territorial dispersion by planning more lively and diverse urban conglomerates?

As an analytic and interpretative tool, our model proved to be able to provide the insights needed to answer to this questions. However, as the matters is highly context-sensible and debatable at times, it is left to the planners and the stakeholders to interpret

the results made possible by our territorial analyses. The model is just a tool and as such has to be used as a basis for taking more informed decisions that still have to be taken by experts and knowledgeable local decisionmakers.

- Upon which ground can we defend the choice on which location are worth to be re-urbanized and which are not?

This is an interesting point that also has been raised during our conversation with the head of the bureau of the PDM at the Municipality of Sintra, Tiago Trigueiros. He expressed a concern regarding the recent abolition of the "urbanizable areas" as he reported that one of the main difficulties for the municipality has been to explain to landlords why a specific area that was once considered urbanizable should now return to be classified as rural. Our model set to explain such rationale by making evident how different factor corroborate those policy decision and can even illustrate the pros and contra of such decisions. On the other hand, what we proved in our work is that not all the locations that may fell previously under the same categorization are all the same and that even within dispersed urban territories there are locations worth of being intensified or invested by projects of territorial acupuncture.

To summarize, the present work, by proposing a novel approach to the integration of different kinds of territorial analysis and of principles translated from the concept of territorial capital into a traditional process of urban planning at municipal or supra-municipal level, responds to some of the main challenges that local planning in Portugal faces at the moment: namely regarding land use classification, disappearance of urbanizable areas and shrinking urban perimeters. Knowing, in the context of scattered urban areas, which places / location have by their very nature the greatest potential to address future urbanization / intensification over others, is a key aspect of the planning process in circumstances such those of today's Portuguese context.

10.2.2 The perspective of the operative framework for decision-making support for territorial planning

As we mentioned in section 10.1, the present work provides a set of contributions to the operative field of territorial analyses and decision-making support tools for territorial planning. As we intended the two perspectives – the one of the planning discipline and the one, this illustrated here, of the instrumental innovations needed to support the planning practice – inseparable, we developed an integrated approach capable of supporting the planning process in its analytical and decision-making phases by providing layers of information useful as a basis upon which ground strategic plans and decisions.

The questions – and the related answers – related to these topics are:

- How can we measure and spatialize the elements that concur to the definition of the territorial capital of a specific region in order to be able to embed those findings in a planning process?

As a response to this question the work developed a theoretical structure then translated into an operational framework for urban and regional planning. Such framework incorporates a set of analytical methods based on computational tools that allowed for an holistic view over the planning process. By incorporating layers of information from a varied set of fields into a single reporting structure, we constructed a multidisciplinary framework capable of guiding through complex decision making processes such as territorial development scenarios and regional governance.

The data-driven character of the analyses and the choice of employing a custom reporting grid that help to homogenize and compare data from different sources and realms, made possible to translate the whole spectrum of territorial capital features and variables into our operational model.

- How can we translate generic strategic plans into detailed territorial development plans?

In the present work we argue and demonstrate that this is possible with two steps. First, by giving a spatial expression to many of the strategic directions expressed in PDM documents and reports. Secondly, by enabling a kind of understanding of the territorial dynamics, behaviors, vocations of the place that are only possible by integrating the most diverse and meaningful territorial analysis in one single model. Such spatialized and holistic view over the territory constitute the basis to build a decision-making support tool for territorial development plans. In this work we concentrated on the analytic side of the model, giving stakeholders a tool to visualize and interpret territorial features and dynamic but leaving for a future work the development of heuristic functions capable of supporting decision-making processes.

- How can we design an analytical framework capable of guiding in the decision-making process of developing municipal and regional masterplans that can be easily scalable and reproducible?

The operational framework proposed in this thesis is built on the observation that many planning endeavours struggle to incorporate different views and disciplines into one single model failing at looking at the territory from a multidisciplinary perspective when it comes to strategic planning. Such framework incorporates a set of analytical methods based on computational tools that allowed for an holistic view over the planning process. The main focus has been from the beginning to incorporate layers of information from a varied set of fields into a single reporting structure, this in order to compose a multidisciplinary framework capable of guiding through complex decision making processes such as territorial development scenarios and regional governance.

- Is it possible to integrate a normative tool with strategic development tool inside of a PDM process of revision?

The case of Sintra's PDM revision offered an emblematic example of the attempts to combine the two, as it tries to combine both a normative planning tool and a strategic development tool. Moreover, the proposed framework, while contributing to

homogenize the inputting of different datasets from different sources and disciplines into one territorial model, also set the structure to integrate normative planning and development strategies into a single framework. This ultimately allows to test development scenarios and territorial strategic plans into a single platform. By doing so we successfully explored the possibility of embedding territorial capital analyses and considerations into a more traditional planning framework, filling the gap between normative regulations and strategic planning.

To summarize, the present work introduces an operative framework capable to guiding the process of decision-making in the context of local planning. It does that by successfully integrating information and data from different fields and expertise into the territorial model, additionally creating the infrastructure to embed the concepts and the calculations needed to incorporate the concept of territorial capital into the model permitting the full integration of the latter into the decision-making process of local planning.

10.3 Achievements and contributions

The model proposed in the thesis provides a framework for the quantitative assessment of territorial indicators and for the definition of territorial profiles to be used in scenario making and evaluation. Our pilot test proved to be capable of successfully integrating these function into one single framework that can constitute the basis for a multidisciplinary decision-making support tool for municipal and supra-municipal planning processes.

The main scientific contributions of the thesis are:

- A theoretical model capable of successfully integrating different layers of information into a municipal or regional planning process, involving a GIS platform and a data standardization process. Therefore, the thesis contributes to the field of computational methods applied to planning theory.
- The model provides a standardized platform for reporting results and data with a custom grid 100x100m based on a refined version of the 1x1km grid proposed by the EU. Such reporting structure allows for the analysis of different datasets from different sources and fields in one single view. Therefore, the thesis contributes to the field of geographic data representation.
- By intersecting data from different fields and using them in order to perform territorial analysis cross-disciplinary territorial analyses, this thesis contributes to the development of cross knowledge-based analyses for municipal and regional planning.
- A novel method for spatializing the results of a traditional SWOT analysis has been successfully tested in this work, contributing to introducing a new way to integrate SWOT analyses into the planning process. The framework constructed for this work, with its reporting grid and its set of indicators coming from different dimensions of the territorial analyses realm, proved to be a valid tool in spatializing the findings of the SWOT analysis.

- A method for territorial profiling involving different scores for different indicators has been successfully tested in this work contributing to a novel approach to territorial capital analyses and profiling.
- Moreover, a set of recommendations for developing software for urban planning, namely in terms of how it should be structured to support datasets interoperability, has been presented. This contributes to the field of computational methods applied to urban planning.
- An overall data-driven method to enhance the quality of a planning process, based on an information flow that supports design decisions in planning processes, has been successfully employed and presented in this work. This contributes to the field of computational methods applied to urban planning as well as to territorial planning practice. The method enables design decisions to be rooted in better grounded information.
- A tool for supporting studies on the relationships between urban morphology and territorial capital. This contributes to urban morphology studies by improving awareness of the relationships between urban morphology and territorial capital.

The contributions made by this work to planning practice are likely to be amenable to a real-world integration in municipal and supra-municipal plans, improving the quality of territorial planning, its management and response to the complexity of the extensive territories.

The improved integration between different datasets coming from different disciplines + is also likely to improve the efficiency of the solutions to propose for the territory as well as to improve the exchange of information and the participatory processes in the sense that the proposed system allows for comparison with alternative scenarios and provides multidisciplinary data for each scenario to support decision-making.

With this model, stakeholders are in a much better position to evaluate planning scenarios and territorial analyses in order to take more informed decisions. Ultimately, the approach proposed in this work helps providing a solid theoretical and operational foundation for the planning and governance of more sustainable territories, at least in the sense that it offers a greater capacity for designing plans that both adapt to the actual territorial capital of the place and have the capacity to adapt to the changing situation of territorial capital.

10.4 Validity of the model

Here, one could question a couple of aspects that – as we illustrated above – are at the basis of this work:

- First, how the methodology proposed in this work proceeds to the integration of such diverse set of analyses and data coming from different domains and of different nature (such as density studies, network analyses, socio-economic data)?

- Secondly, how such integration of data from different sources and different domains could lead us to the implementation of a model capable of guiding through a process of scenario-making and scenario evaluation for the territorial development of Sintra, testing in addition the different potential in re-urbanization for each location in the territory?

As we have seen in the previous chapters, the territorial analysis model implemented in the present work is structured in a way to be capable of incorporating data from very different realms. These different realms reflect the four dimensions upon which the territorial model is developed (see section 4.8). With the integration of such a diverse array of data and analyses coming from such different dimensions, the present work succeeded at developing its own territorial capital matrix, therefore being able to constitute a valuable tool for supporting decision makers in strategic planning processes over the municipal territory.

Moreover, most of the results of the territorial analyses that we performed showed a high correspondence to the results presented in the PDM revision, with only one exception: the degree of detail that we achieved with the proposed disaggregation of data made the territorial profiling much more accurate enabling the detection of territorial dynamics that would have gone unnoticed with the resolution proposed by the PDM of Sintra as well the datasets by the INE. This fact proved once again the validity of the model.

10.5 Challenges and limitations

The main challenges and limitations of this work have been:

- The issue of the access to the data. This has the potential to hinder any data-driven approach to the study of territorial development. As we have seen during our work, the availability of open data in Portugal is very limited constituting a serious threat for the development of works like this one. In our work, in the SWOT analysis for example, some statements were not capable of being supported by a spatialization process because we weren't granted access to the related data.
- The challenge of interpreting many parameters/indicators as they are subjective sometimes and hard to support in theory. This is the case of a few indicators, whose meaning can be interpreted in different ways depending by the goal, the context and the intentions. But also the grouping of such indicators constitute a challenge as one could argue that there could be other ways to group them.
- The challenge of subdiving in categories the values of each indicator in different classes in order to be able to determine breaks and assign ranks to each class of values is a difficult one to support with theoretic evidence – just with a lot of experimentation and empirical knowledge it is possible to solve take this decisions.

- The challenge of spatial disaggregation. Although we followed the best practices around, the disaggregation step is always an issue. To find a way to disaggregate data that arrive already aggregated is not an easy one. Much better would be to be able to start with a dataset created having as a basis our reporting grid.

10.6 Potential developments and future work

During the course of this study, many topics have arisen suggesting alternative and further

research paths that could not be carried out in the timeframe of this work. Here you can find some of these possible future paths:

- Implement a system for the continuing monitoring of the territorial capital with the goal of establishing a constant feedback loop with the plan aiming at adapt territorial strategies as the context evolves.
- Due to time constraints, we didn't manage to approach the scenario of the endogenous development. It would be a perfect completion to the work we did about the polycentric territory as we believe that the two aspects (morphological and economical) should go hand in hand in order to combine greater synergies.

We look forward to show the application of our model to experts and stakeholders in order to receive feedback about the use of the model in real-world scenarios, with the aim of fostering the decision-making support factor of the model by implementing AI modules capable of guiding through decision-making.

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APPENDIX

APPENDIX 1 – DISAGGREATION OF DATA

In order to disaggregate the data aggregated by the INE into the BGRI subsections into a more refined system, base on our custom 100x100m grid we prepared some SQL code to do the operation: **CREATE TABLE** results.buildings_grid **AS

SELECT** buildings.**id**,

ST_Intersection(grid.**geom**, buildings.**geom**) **AS** geom,

buildings.**pisos_new AS** pisos,

grid.**id AS** grid_id

FROM model.buildings_permanente **AS** buildings,

results.grid_data **AS** grid

WHERE *ST_Intersects*(grid.**geom**, buildings.**geom**)

ALTER TABLE results.buildings_grid

ADD COLUMN area_implant integer,

ADD COLUMN area_constr integer;

UPDATE results.buildings_grid **SET

area_implant** = *ST_Area*(**geom**),

area_constr = *ST_Area*(**geom**) * **pisos**;

ALTER TABLE results.grid_data

ADD COLUMN permanentes_count integer,

ADD COLUMN permanentes_pisos_mean integer,

ADD COLUMN permanentes_pisos_max integer,

ADD COLUMN permanentes_area_implant integer,

ADD COLUMN permanentes_area_constr integer,

ADD COLUMN fator double precision;

```
**UPDATE** results.grid_data **AS** grid **SET
   permanentes_count** = b.count,
   **permanentes_pisos_mean** = b.pisos_mean,
   **permanentes_pisos_max** = b.pisos_max,
   **permanentes_area_implant** = b.area_implant,
   **permanentes_area_constr** = b.area_constr
   **FROM** (
      *-       **SELECT grid_id**,
         *count*(***) **AS count**,
         *avg*(**pisos**) **AS** pisos_mean,
         *max*(**pisos**) **AS** pisos_max,
         *sum*(**area_implant**) **AS** area_implant,
         *sum*(**area_constr**) **AS** area_constr
      **FROM** results.buildings_grid
      **GROUP BY grid_id**
   ) **AS** b
   *-- juntar os resultados da agragacao a que chamei 'b' a tabela da grid
   -- usando o atributo grid_id*
   **WHERE** grid.**id** = b.**grid_id**;

**UPDATE** results.grid_data **AS** grid **SET
   fator** = **permanentes_area_constr**::**numeric**/b.sum::**numeric
   FROM** (
      **SELECT
         "BGRI11"**,
         *sum*(**permanentes_area_constr**) **AS** sum
      **FROM** results.grid_data
```

GROUP BY "BGRI11"

) **AS** b

WHERE grid.**"BGRI11"** = b.**"BGRI11"**;

APPENDIX 2 – FILTERING OF ECONOMIC ACTIVITIES PER SECTOR

The first sector comprised the economic types of:

"type" = 'Agricultura e Pecuária'

Second sector comprised the economic types of:

"type" = 'industria-fabricantes-grossistas'

OR "type" = 'Barcos e Navios'

OR "type" = 'Construção'

OR "type" = 'Energia'

or "type" = 'Indústria'

or "type" = 'Pedras e Minerais'

or "type" = 'Metais'

or "type" = 'Produtos Químicos'

Third sector comprised the economic types of: "type" = 'Alimentação'

or "type" = 'Arte e Artesanato'

or "type" = 'Artes Gráficas'

or"type" = 'Audiovisuais'

or "type" = 'Automóveis'

or "type" = 'Bebés e Crianças'

or "type" = 'Beleza'

or "type" = 'Ciência'

or"type" = 'Cultura e Lazer'

or "type" = 'Desporto'

or "type" = 'Diversos'

or "type" = 'Ensino'

or "type" = 'Grossistas'

or "type" = 'Grupos'

or "type" = 'Hotelaria'

or "type" ='Informática'

or "type" = 'Lar'

or "type"='Media'

or "type"='Moda'

or "type"='Mobiliário e Decoração'

or "type" ='Motorizadas e Motos'

or "type"='Negócios'

or "type"='Produtos Químicos'

or "type"='Publicidade e Marketing'

or "type"='Retalhistas'

or "type"='Saúde'

or "type"= 'Segurança'

or "type"='Seguros'

or "type" = 'Serviços'

or "type"= 'Transportes'

or "type"='Turismo'

or "type" = 'Têxteis'

or "type"= 'automoveis-motos-barcos'

or "type" = 'comercio'

or "type" = 'construcao-decoracao-imobiliarias'

or "type"='educacao'

or "type" = 'eventos'

or "type" = 'instituicoes'

or "type" = 'lazer-cultura-desporto'

or "type"='marketing-ti-comunicacao'

or "type"='restauracao'

or "type" = 'saude-3'

or "type" ='servicos'

or "type" ='transportadoras-logistica-e-transportes'

or "type" ='Água e Ecologia'

or "type" = 'Animais'

or "type" = 'Aviões'

or "type" = 'Barcos e Navios'

or "type" = 'Imobiliário'

or "type" = 'Madeira'

or "type" = 'Metais'

or "type" = 'Produtos Químicos'

APPENDIX 3 - SCALING OF TERRITORIAL INDICATORS

Population having completed at least secondary education - share

```
CASE
WHEN "enssup_share"  < 0.037 THEN '1'
WHEN  "enssup_share"  >= 0.037 AND "enssup_share"  < 0.135  THEN '2'
WHEN  "enssup_share"  >= 0.135 AND "enssup_share"  < 0.233  THEN '3'
WHEN  "enssup_share"  >= 0.233 AND "enssup_share"  < 0.349  THEN '4'
WHEN  "enssup_share"  >= 0.349   THEN '5'
ELSE 'none'
END
```

Population over 65 years old - share

```
CASE
WHEN "over65_share"  < 0.03407 THEN '1'
WHEN  "over65_share"  >= 0.03407 AND "over65_share"  < 0.13458 THEN '2'
WHEN  "over65_share"  >= 0.13458 AND "over65_share"  < 0.29813 THEN '3'
WHEN  "over65_share"  >= 0.29813 AND "over65_share"  < 0.43782 THEN '4'
WHEN  "over65_share"  >= 0.43782 THEN '5'
ELSE 'none'
END
```

New Dwellings 1991-2011 - share

```
CASE
WHEN "num_edif_new_share" < 0.17 THEN '1'
WHEN  "num_edif_new_share" >= 0.17 AND "num_edif_new_share" <0.77  THEN '2'
WHEN  "num_edif_new_share" >= 0.77  AND "num_edif_new_share"< 2.00 THEN '3'
WHEN  "num_edif_new_share" >= 2.00 AND "num_edif_new_share" < 4.00 THEN '4'
WHEN  "num_edif_new_share" >= 4.00  THEN '5'
```

```
ELSE 'none'
END
```

Unemployed looking for a job - share

```
CASE
WHEN "desemp_share"  < 0.034 THEN '1'
WHEN  "desemp_share"  >= 0.034 AND "desemp_share"  < 0.068  THEN '2'
WHEN  "desemp_share"  >= 0.068   AND "desemp_share"  < 0.101  THEN '3'
WHEN  "desemp_share"  >= 0.101 AND "desemp_share"  < 0.131  THEN '4'
WHEN  "desemp_share"  >= 0.131  THEN '5'
ELSE 'none'
END
```

Population density - normalized

```
CASE

WHEN "pop_ha_normal" < 0.027 THEN '1'

WHEN  "pop_ha_normal" >= 0.027 AND "pop_ha_normal" < 0.080  THEN '2'

WHEN  "pop_ha_normal" >= 0.080   AND "pop_ha_normal" < 0.181  THEN '3'

WHEN  "pop_ha_normal" >= 0.181 AND "pop_ha_normal" < 0.349  THEN '4'

WHEN  "pop_ha_normal" >= 0.349  THEN '5'

ELSE 'none'

END
```

Gross Space Index (GSI) - normalized

```
CASE

WHEN "GSI_normal" < 0.068 THEN '1'

WHEN  "GSI_normal" >= 0.068 AND "GSI_normal" < 0.199  THEN '2'

WHEN  "GSI_normal" >= 0.199   AND "GSI_normal" < 0.334 THEN '3'

WHEN  "GSI_normal" >= 0.334 AND "GSI_normal" < 0.501  THEN '4'

WHEN  "GSI_normal" >= 0.501  THEN '5'

ELSE 'none'

END
```

Dispersion index - normalized

```
CASE

WHEN   "dispersion_index_normal"   < 0.083 THEN '1'

WHEN   "dispersion_index_normal"  >= 0.083 AND  "dispersion_index_normal"  <
0.502  THEN '2'

WHEN   "dispersion_index_normal"  >= 0.502 AND  "dispersion_index_normal" <
0.746  THEN '3'

WHEN   "dispersion_index_normal"  >= 0.746 AND  "dispersion_index_normal" <
0.908  THEN '4'

WHEN   "dispersion_index_normal"  >= 0.908 THEN '5'

ELSE 'none'
```

END

Empty dwellings - share

```
CASE

WHEN  "fogos_vagos_share"   < 0.26 THEN '1'

WHEN  "fogos_vagos_share"  >= 0.26 AND "fogos_vagos_share"  < 1.19  THEN '2'

WHEN  "fogos_vagos_share" >= 1.19 AND "fogos_vagos_share" < 2.20  THEN '3'

WHEN "fogos_vagos_share"  >= 2.20 AND "fogos_vagos_share"  < 4.06  THEN '4'

WHEN  "fogos_vagos_share"  >= 4.06  THEN '5'

ELSE 'none'

END
```

Diversity Simpson index - normalized

```
CASE

WHEN  "simpson_index_normal"  < 0.17 THEN '1'

WHEN  "simpson_index_normal" >= 0.17 AND "simpson_index_normal" < 0.46
THEN '2'

WHEN  "simpson_index_normal">= 0.46 AND "simpson_index_normal"< 0.67  THEN
'3'

WHEN  "simpson_index_normal" >= 0.67 AND "simpson_index_normal" < 0.89
THEN '4'

WHEN  "simpson_index_normal" >= 0.89  THEN '5'

ELSE 'none'

END
```

Number of acivities 1st sector - share

```
CASE

WHEN     "sect_1_share"    < 0.004 THEN '1'

WHEN    "sect_1_share"   >= 0.004 AND    "sect_1_share"   < 0.027  THEN '2'

WHEN     "sect_1_share"   >= 0.027 AND    "sect_1_share"  < 0.053  THEN '3'

WHEN     "sect_1_share"   >= 0.053 AND    "sect_1_share"    < 0.1  THEN '4'
```

```
WHEN      "sect_1_share"    >= 0.1 THEN '5'
ELSE 'none'
END
```

Number of acivities 2nd sector - share

```
CASE
WHEN "sect_2_share" < 0.05 THEN '1'
WHEN "sect_2_share" >= 0.05 AND "sect_2_share" < 0.18 THEN '2'
WHEN "sect_2_share" >= 0.18 AND "sect_2_share" < 0.33 THEN '3'
WHEN "sect_2_share" >= 0.33 AND "sect_2_share" < 0.67 THEN '4'
WHEN "sect_2_share" >= 0.67 THEN '5'
ELSE 'none'
END
```

Number of acivities 3rd sector - share

```
CASE
WHEN "sect_3_share" < 0.062 THEN '1'
WHEN "sect_3_share" >= 0.062 AND "sect_3_share" < 0.2 THEN '2'
WHEN "sect_3_share" >= 0.2 AND "sect_3_share" < 0.4 THEN '3'
WHEN "sect_3_share" >= 0.4 AND "sect_3_share" < 0.769 THEN '4'
WHEN "sect_3_share" >= 0.769 THEN '5'
ELSE 'none'
END
```

Choice 5km radius - normalized

```
CASE
WHEN "ch5kmax_normal" < 0.011 THEN '1'
WHEN "ch5kmax_normal" >= 0.011 AND "ch5kmax_normal" < 0.033
THEN '2'
WHEN "ch5kmax_normal" >= 0.033 AND "ch5kmax_normal" < 0.143
THEN '3'
```

```
WHEN "ch5kmax_normal" >= 0.143 AND "ch5kmax_normal" < 0.366
THEN '4'

WHEN "ch5kmax_normal" >= 0.366 THEN '5'

ELSE 'none'

END
```

Integration 5km radius - normalized

```
CASE

WHEN "sum5kintw_normal" < 0.089 THEN '1'

WHEN "sum5kintw_normal" >= 0.089 AND "sum5kintw_normal" < 0.481
THEN '2'

WHEN "sum5kintw_normal" >= 0.481 AND "sum5kintw_normal" < 0.579
THEN '3'

WHEN "sum5kintw_normal" >= 0.579 AND "sum5kintw_normal" < 0.697
THEN '4'

WHEN "sum5kintw_normal" >= 0.697 THEN '5'

ELSE 'none'

END
```

Infrastructure density - normalized

```
CASE

WHEN "allroads_l_normal" < 0.041 THEN '1'

WHEN "allroads_l_normal" >= 0.041 AND "allroads_l_normal" < 0.115
THEN '2'

WHEN "allroads_l_normal" >= 0.115 AND "allroads_l_normal" < 0.205 THEN
'3'

WHEN "allroads_l_normal" >= 0.205 AND "allroads_l_normal" < 0.353
THEN '4'

WHEN "allroads_l_normal" >= 0.353 THEN '5'

ELSE 'none'

END
```

Number of culs-de-sac

```
CASE

WHEN       "culdesac_normal"     < 0.050 THEN '1'

WHEN      "culdesac_normal"   >= 0.050 AND      "culdesac_normal"    < 0.221  THEN
'2'

WHEN        "culdesac_normal"    >= 0.221 AND       "culdesac_normal"    < 0.462
THEN '3'

WHEN       "culdesac_normal"     >= 0.462 AND      "culdesac_normal"       < 0.759
THEN '4'

WHEN        "culdesac_normal"     >= 0.759 THEN '5'

ELSE 'none'

END
```

APPENDIX 5 - TERRITORIAL PROFILING

Lively urban centre

"num_edif_new_scale_share" >= 1 AND

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" >= 3 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" >= 5 AND

"simpson_index_scale" >= 4 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 2 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 2

Not lively urban centre

"num_edif_new_scale_share" >= 1 AND

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" >= 3 AND

"fogos_vagos_share_scale" >= 2 AND

"dispersion_index_scale" >= 5 AND

"simpson_index_scale" <= 3 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 2 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 2

Lively dispersed area

"num_edif_new_scale_share" >= 1 AND

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" >= 1 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" <= 3 AND

"simpson_index_scale" >= 3 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 1 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 2

Not lively dispersed area

"num_edif_new_scale_share" >= 1 AND

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" >= 1 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" <= 3 AND

"simpson_index_scale" <= 3 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 1 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 1

Dispersed Area with potential of becoming a place

"num_edif_new_scale_share" >= 1 AND

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" >= 2 AND

"fogos_vagos_share_scale" >= 1 AND

"dispersion_index_scale" >= -3 AND

"simpson_index_scale" >= 3 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 1 AND

"choice_r5k_norm_scale" >= 1 AND

"integr_r5k_norm_scale" >= 2

Dispersed Area with potential of becoming a node

"pop_ha_scale_normal" >= 1 AND

"GSI_scale_normal" <= 2 AND

"fogos_vagos_share_scale" >= 1AND

"dispersion_index_scale" <= 4 AND

"simpson_index_scale" >= 1 AND

"num_act_ter_scale_share" >= 1 AND

"allroard_l_normal_scale" >= 1AND

"choice_r5k_norm_scale" >= 4 AND

"integr_r5k_norm_scale" >= 1